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ENHANCING INTERNAL ILLUMINATION IN A SPORTS COMPLEX USING PASSIVE ARCHITECTURAL DESIGN APPROACH.

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ABSTRACT

This research explores the crucial dimensions of quality, distribution, and sustainability in illumination within sports complexes, emphasizing the interplay between architectural context, strategic design measures, and factors such as light distribution, source characteristics, and directionality. Beyond artificial lighting, the study delves into passive daylighting solutions, investigating the role of skylights, sun portals, and high-performance glazing in optimizing internal illumination. The multifaceted challenge of enhancing internal illumination in sports complexes requires a holistic approach that aligns with sustainability principles and visual comfort metrics. The literature review highlights the significance of consistent light levels, visual comfort metrics, and the under-exploitation of natural resources, particularly daylight. Daylighting solutions, including skylights, sun portals, high-performance glazing, and light shelves, are explored. The lighting requirements for sports facilities, energy-efficient solutions, and a case study of Northumbria University Sports Central are presented. The discussion emphasizes functional lighting requirements, human-centric lighting, energy-efficient solutions, uniform illumination, adaptability for different sports, glare control, and maintenance considerations in sports complex illumination.

1.0 INTRODUCTION

Odediran et al. (2012) stated that the ability of a building to provide the required environment for a particular activity is a measure of its functionality. The absence of sufficient lighting while engaging in an activity has been known to bring about the onset of eye-related conditions. Visual comfort, a cornerstone of the sports complex experience, is intricately tied to the luminous environment; emphasizing the interplay between a complex's architectural context, strategic design measures and considerations that extend to factors such as light distribution, source characteristics, and directionality. Recognizing that the mere provision of light is no longer adequate, the pivotal dimensions of quality, distribution, and sustainability in illumination have emerged as critical factors shaping the future of sports complex design. In the pursuit of optimizing internal illumination, the research navigates through the intricacies of indoor lighting design, focusing on the strategic integration of passive architectural design approaches to elevate the quality and efficiency of internal lighting systems.

Beyond artificial lighting, the exploration extends into the realm of passive daylighting solutions. Daylight, not merely an alternative but a complement to artificial illumination, is showcased as a contributor to enhanced recreational experiences, athlete comfort, and elevated performance. The multifaceted challenge of enhancing internal illumination in sports complexes requires the implementation of techniques such as skylights, sun portals, and high-performance glazing; emphasizing the role of architectural elements in controlling daylight intensity and minimizing glare thereby, creating a holistic approach to internal illumination in sports complexes that not only meet functional requirements but also align with the principles of sustainability and visual comfort.

2.0 LITERATURE REVIEW

Simply having light may not be sufficient, and even ample light can be poorly distributed or diminished in various ways before reaching the eyes. According to Gellings (2009), the measurement of illumination is expressed in footcandles or lux. However, assessing the quantity of illumination involves more than simply turning on the lights. It's essential to understand that the eye perceives brightness, not just illumination. In reality, much of artificial illumination is often reflected by surfaces, leading to varying usable illumination from a source. This reflected light is termed brightness and is measured in foot-lamberts (or candela per square meter).

Internal illumination is a critical aspect of a sports complex design, which influences athlete performance, spectator experience, and overall safety. Enhancing internal illumination in a sports complex is a multifaceted challenge that involves considerations of functionality, aesthetics, and energy efficiency. When defining lighting needs, it is essential to ascertain the nature of expected activities, their duration, the density of people, and their specific locations (Gellings, 2009). As technology advances, there is a growing focus on optimizing lighting solutions to meet the diverse needs of different sports and events. The importance of ensuring a consistent level of light, a fundamental requirement, cannot be overstated in maintaining the enjoyment of sporting activities. This becomes particularly critical when objects move between spaces of varying light intensities, potentially leading to harm or injury (Velux,2023).

According to Cadena et al. (2022), the indoor luminous environment is shaped by the interplay between the building's surrounding context and the strategic measures incorporated during the design phase. These measures encompass the building's shape and orientation, as well as the properties of glazing and shading, involving the integration and improvement of dynamic shading devices and lighting applications. The assessment of visual comfort primarily relies on the measurement of light intensity reaching a surface, either vertically (Ev) or horizontally (Eh), expressed in lux (Cadena et al., 2022). Consequently, visual comfort metrics typically consider factors such as light intensity, distribution, source, and directionality, essential for the safe and fatigue-free performance of activities in the designated area.

Nabil and Mardaljevic (2006) highlight the under-exploitation of natural resources, particularly daylight. He emphasised the exploitation of daylight as an effective means to reduce the artificial lighting requirements of non-domestic buildings; providing crucial information about illuminance levels of useful daylight and also identifying the potential for excessive illuminance leading to occupant discomfort and unwanted solar gain. As referenced by Cadena et al. (2022), Ko et al. (2021) state that the quality of the view facilitated by window light involves a combination of view content (what is observable), view access (the extent of the visible view for the occupant), and view clarity (how clearly the content is visible, influenced by window properties).

Nabil and Mardaljevic (2006) also demonstrate the application of useful daylight illuminance, UDI in analysing design variants for a deep-plan building with a light well, comparing it with traditional approaches like the daylight factor and LEED daylight credit.

Studies have indicated that visual performance is significantly improved on light-coloured tasks when the illumination levels are raised to about 500-foot candles (5400 lux). This level of illumination is about the same as that found under the shade of a tree on a sunny day—certainly, a pleasant spot to read. There are also many dark-coloured or lower reflectance tasks, where visual

performance continues to improve when levels up to 10,000-foot candles (108 000 lux) are utilized. This is the level of illumination under full sunlight (Gellings, 2009). People who "work with their eyes" not only accept but instinctively desire, the hundreds of foot-candles that can be available to them today.

In the evaluation of environmental parameters, it is crucial to incorporate specific performance criteria to ensure a precise assessment of occupant-centred visual comfort. These criteria should include:

1. the luminance of the glare source;
2. illuminance on the eye-plane;
3. adaptation level;
4. contrast effect;
5. size of the glare source;
6. position of the glare source.

While it should likely consider:

1. saturation effect;
2. light resulting spectrum;
3. light colour temperature. (Pierson et al, 2018 as cited in Cadena et al, 2022).

2.1DAYLIGHTING SOLUTIONS

Daylight solutions enhance the recreational experiences of individuals using sports facilities, contributing to the comfort of athletes and elevating their performance. Therefore, illuminating spaces doesn't necessarily necessitate the use of electricity, particularly in the daytime (Velux, 2023).

Techniques for lighting during this period have been provided, some of which will include;

2.1.1 Skylight: As one of the passive design strategies for lighting, skylight is utilised because of the amount of light it brings into a space, which also doubles down as a source of ventilation.

Figure 2.1: Skylight for Daylighting

Source: https://www.architectmagazine.com/technology/lighting/5-surprising-daylighting-strategies

2.1.2 Sun Portal: Also known as Solar Tube, and Optic Solar Cable, the Sun Portal is a mechanism that works by collecting daylight through the aid of a convex glass and conveying it via a tube with reflective properties into the internal spaces (Bredenberg, 2012)

Figure 2.2: Sun Portal System

Source: https://inhabitat.com/sunportal-uses-pipes-to-deliver-daylighting-anywhere-within-a-building/sunportal-daylighting-natural-daylight-solar-light-pipes-bender-relay/

Controlling the intensity of daylight is another aspect of the passive daylighting technique that stresses the kind of materials used.

2.1.3 HIGH-PERFORMANCE GLAZING: Minimizing glare is crucial to avoid dazzling or disorienting athletes. High-performance glazing is employed to allow light penetration while mitigating heat gain, resulting in an improved solar heat gain coefficient within the building (Norris, 2019; H M Taleb, 2014)

Figure 2.3: High-Performance Glazing

Source: https://passivehouseaccelerator.com/articles/five-principles-of-passive-house-design-and-construction

Different glazing can now be selected based on its performance capabilities to satisfy a variety of needs, including the use of semi-transparent glazing to deliver illumination without glare and shadows (Velux, 2023).

2.1.4 LIGHT SHELVES: This has become an important iconic component in many commercial buildings. It is constructed of metal, painted wood, or gyp-board and is located on the south on the walls of buildings separating a lower "vision-glass" from an "upper daylight glass".

Figure 2.4: Light Shelves

Source: http://www.2030palette.org/intermediate-light-shelves/

They are always white for reflective but some have mirrored tops. The purpose of the light shelf is to bounce the sunlight deeper into the space without causing glare, to reduce the difference in light levels at the front of the room and deep within the room, and to block heat gain from entering the main vision window during the cooling season on the external portion.

2.2LIGHTING REQUIREMENTS FOR SPORTS FACILITIES

Sports complexes, designed for multiple purposes, must accommodate distinct requirements for each sporting event and competition level. Ensuring uniform light distribution can be a challenge in more extensive areas such as sports halls when hosting activities spanning from beginner to advanced levels, particularly when relying on artificial lighting (Velux,2023). The lux level criteria vary depending on the types of sports taking place within a sports hall. Standard ball sports typically call for 200 lux, whereas high-speed ball sports like squash require a higher intensity of 300 lux (Walton, 20). To facilitate sports competitions, a sports hall must meet a minimum requirement of 500 lux with an adjustable lighting system to meet the specific requirements of activities. Additionally, specific values, such as illuminance, uniformity, glare restriction, and the colour characteristics of the light sources, need careful monitoring (Gossen, 2023).

According to Cadena et al. (2022), enhancing the operational efficiency and interoperability of lighting systems can considerably improve a building's energy efficiency and comfort. Hence, artificial lighting should only supplement natural light to meet specific minimum requirements for each task when natural light is insufficient, to prevent the onset of eye-related conditions. To minimize energy consumption, especially given the high lighting requirement for sports complexes, a combination of natural and artificial lighting sources is recommended. This might involve employing an energy-efficient LED light source with daylight-dimming capabilities (Walton, 2023). Luminaires equipped with the RIC® (remote intelligent control) system dynamically adjust their brightness in response to high levels of natural light penetration, ensuring a constant level of lux and uniformity, ultimately reducing the overall energy usage (Walton, 2023).

3.0.RESEARCH METHODOLOGY

A descriptive case study research approach was used in studying and understanding internal illumination and how its enhancement through passive architectural design approaches and strategic measures incorporated during the design phase can improve the functionality of a sports complex. Analysing the data required an understanding of illumination and the quantity and/or illuminance levels of useful daylight required for the eye to perceive brightness and also identifying the potential for excessive illuminance leading to occupant discomfort and unwanted solar gain; using the Northumbria University Sports Central, Newcastle as a case study.

4.0 CASE STUDY

4.1 THE NORTHUMBRIA UNIVERSITY SPORTS CENTRAL, NEWCASTLE

Figure 4.1: Aerial View of the North Umbria University Sports Central

Source: Google Earth (2022)

The Northumbria University Sport Central building includes a 3,000-seat arena, a 25-metre swimming pool, a climbing wall and an indoor running track alongside sports research laboratories.

Figure 4.2: The North Umbria University Sports Central, Atkins Project, Newcastle

Source: The Architects Journal (2022)

The Atkins project has achieved a BREEAM Excellent rating by featuring techniques like rainwater harvesting to top up the swimming pool. Anodized aluminium cladding is used on external facades to provide visual interest while semi-translucent cladding panels are featured at higher levels to allow natural light into the building.

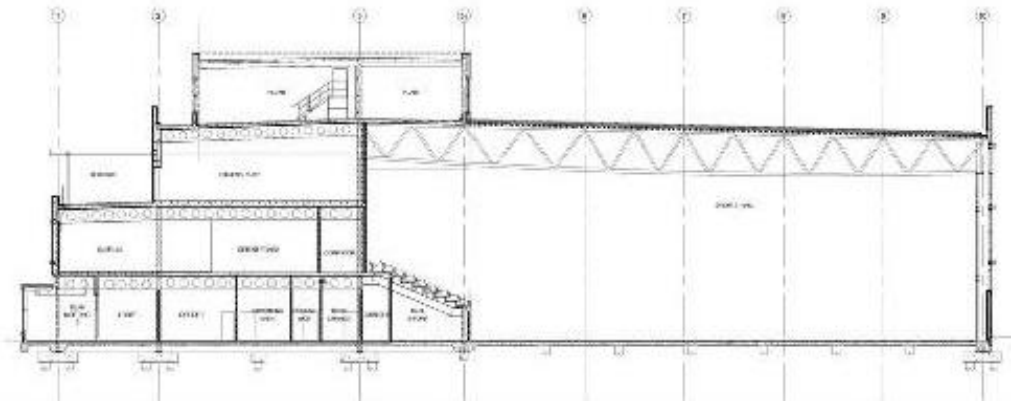

Figure 4.3: Section A showing the interior of Northumbria University Sports Central

Source: The Architects Journal (2022)

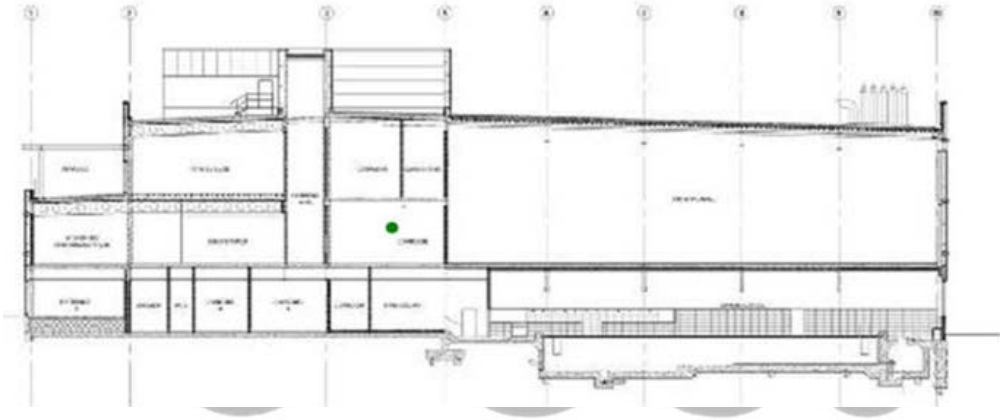

Figure 4.4: Section B showing the interior of Northumbria University Sports Central

Source: The Architects Journal (2022)

On the southern façade, a thin vertical slot of structural glass allows passers-by to see the multi-story climbing wall inside the building.

Inside, the arena uses movable seats which means it can be tailored to specific events. When not in use the space can be converted into three separate sports halls.

Figure 4.5: Showing Sports Hall with Adjustable Seating, a sustainability initiative

Source: The Architects Journal (2022)

Figure 4.6: Showing West Elevation of Northumbria University Sports Central

Source: The Architects Journal (2022)

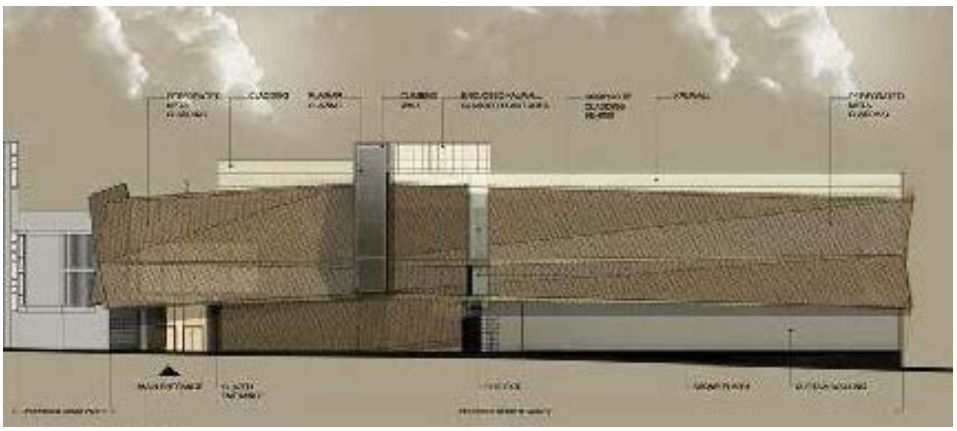

Figure 4.7: Showing North Elevation of Northumbria University Sports Central

Source: The Architects Journal (2022)

Four white rectangular pods are built on the western façade, three contain meeting and teaching facilities and the fourth serves as the main entrance.

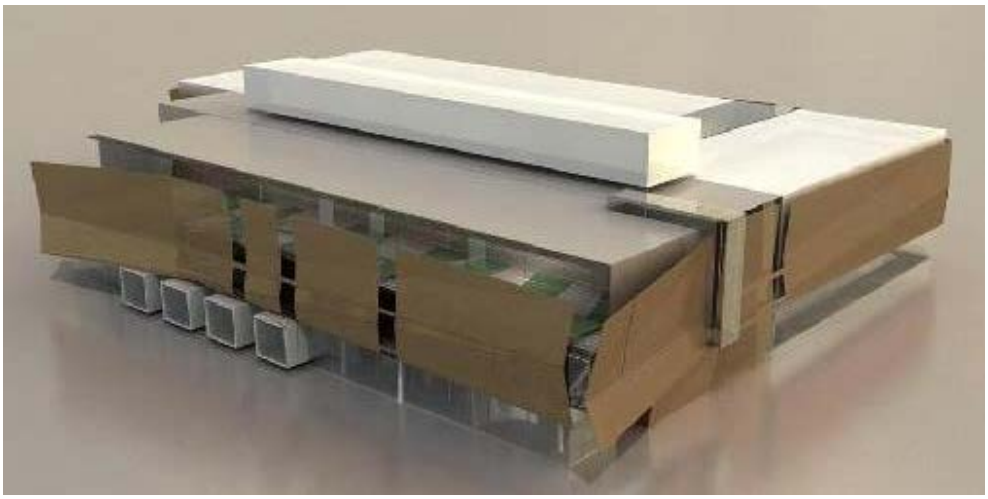

Figure 4.8: 3-D image of the Northumbria University Sports Central

Source: The Architects Journal (2022)

Figure 4.9: Showing Anodized Aluminum Cladding, a sustainability initiative

Source: The Architects Journal (2022)

5.0 DISCUSSION

Enhancing internal illumination in a sports complex is a multifaceted challenge that involves considerations of functionality, aesthetics, and energy efficiency. Drawing insights from reputable sources, this discussion will delve into key aspects of achieving optimal lighting in sports complexes.

5.1 Functional Lighting Requirements: Internal illumination in a sports complex should first and foremost meet the functional requirements of various activities. According to Gellings (2009), understanding the intended uses of different spaces within the complex is crucial for tailoring lighting solutions to specific needs. For instance, the lighting requirements for a basketball court would differ from those of a swimming pool area.

5.2 Human-Centric Lighting: The concept of human-centric lighting, as discussed by Nabil and Mardaljevic (2006) and Pierson et al (2018), identifies the potential for excessive illuminance from natural sources, leading to occupant discomfort and unwanted solar gain. This loosely translates into designing lighting systems that consider the well-being and performance of individuals. For a sports complex, this implies incorporating lighting solutions that support the visual comfort and circadian rhythms of athletes, coaches, and spectators alike (Pierson et al, 2018).

5.3 Energy-Efficient Solutions: Emphasizing the importance of energy-efficient lighting aligns with global sustainability goals. As per recommendations in "Lighting a Sports Hall" (Walton, 2023), utilizing LED lighting technology and incorporating intelligent controls can optimize energy consumption in a sports complex without compromising illumination quality.

5.4 Uniform Illumination: Achieving uniform illumination is essential for sports venues. Velux (2023) discusses how a balanced and even distribution of light across the playing field or arena helps eliminate shadows and provides a clear visibility advantage. This is critical for both players and spectators.

5.5 Adaptability for Different Sports: A comprehensive approach to lighting design, as outlined by Walton (2023) involves creating adaptable systems that cater to different sports events within the complex. Lighting should be adjustable to meet the specific requirements of activities ranging from indoor football matches to swimming competitions (Walton, 2023),

5.6 Glare Control: Addressing the issue of glare is paramount in sports complex illumination where excessive glare can impede visibility and create discomfort. Norris, 2019 and Taleb (2014) suggest the incorporation of fixtures and positioning strategies such as high-performance glazing that allow light penetration, minimize glare and mitigate heat gain, resulting in an improved solar heat gain coefficient, and ultimately ensuring a safe and enjoyable environment for both athletes and spectators while within the building

5.7 Maintenance Considerations: Choosing lighting solutions with longevity and ease of maintenance helps ensure consistent and reliable illumination over time, reducing downtime and operational costs.

However, the design issues are complex, as proper provision of natural daylight requires that the form, fabric, internal layout and systems of a building are arranged and integrated appropriately. Architects and engineers need to recognize and balance several factors and the underlying principles to optimize the use of daylight without the inherent problems. By incorporating these principles, the enhancement of internal illumination in a sports complex can go beyond basic visibility, creating an environment that optimally supports athletic activities, enhances the spectator experience, and aligns with sustainable and human-centric design practices.

6.0 CONCLUSION

Achieving optimal internal illumination in sports complexes involves a multifaceted approach, considering functionality, aesthetics, energy efficiency, and human-centric design. The study underscores the importance of understanding the diverse lighting needs for different sports and events. It explores passive architectural design approaches and strategic measures, including skylights, sun portals, and high-performance glazing, to enhance both artificial and natural illumination. The case study of Northumbria University Sports Central illustrates how sustainable design practices, such as anodized aluminium cladding and rainwater harvesting, contribute to BREEAM Excellent ratings. The discussion emphasizes the significance of uniform illumination, adaptability for different sports, glare control, and maintenance considerations. By integrating these principles, sports complexes can go beyond basic visibility, creating environments that support athletic activities, enhance the spectator experience, and align with sustainable and human-centric design practices.

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