

The Architectural Design of a Sports Facility in Asahan Regency with a Tropical Architecture Approach

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Abstract: This design project is motivated by the low public interest in sports and the limited availability of sports facilities, creating a need for a sports hall that is both effective and efficient in enhancing the community's quality of life. However, the mere provision of a sports facility is not sufficient; considerations such as building orientation, opening design, and airflow circulation are essential to create an optimal environment for sports activities. Therefore, the tropical architecture approach serves as the primary design basis for the sports hall in Asahan Regency. The aim of this design is to support a healthy lifestyle and improve the quality of life of the local community through comfortable and safe sports activities. The design method adopts a qualitative approach, with data collected through interviews and field observations to understand the needs and preferences of the community. The design also reflects local identity through a mass transformation inspired by the shell form, symbolizing the city of Asahan. The shell structure system is known for its slenderness, making it lightweight and efficient, while its curvature ensures even load distribution. This approach can serve as a model for future sports facility developments in Asahan Regency. This sports hall is expected to become a central hub for athletes in Asahan, providing optimal training facilities to improve their performance. With a modern building and complete facilities, the community can engage in sports activities more comfortably and safely, thus increasing public interest in sports and enhancing overall well-being. This design also aims to promote awareness of the importance of a healthy lifestyle through an effective and efficient sports center.

Keywords: Asahan Regency, Sports, Sports Hall, Tropical Architecture

1. INTRODUCTION

Asahan Regency is a developing region with a population of 802,563 and 1,494 registered athletes as of 2023, according to the Central Statistics Agency (BPS). This number continues to grow, along with the region's thirteen prominent sports disciplines, including Athletics, Volleyball, Taekwondo, Hapkido, Sepak Takraw, Football, and Badminton, among others. Asahan has achieved notable accomplishments in international events such as the 2021 ASEAN Youth Games (Athletics) and the 2022 ASEAN Para Games XI in Solo (Wheelchair Tennis).

Currently, Asahan Regency faces a significant shortage of adequate sports facilities. Existing infrastructures are not only limited in capacity but also fail to meet health and comfort standards for users. The region's hot and humid tropical climate poses a major challenge for outdoor physical activity, discouraging many residents from participating in sports. This situation is further exacerbated by the lack of building designs that respond to local climatic conditions, resulting in sports facilities that are inefficient in managing temperature and humidity.

The growing public awareness of the importance of physical fitness and health has led to increasing demand for more and better sports facilities. The rise of sports culture in Asahan is reflected in the increasing interest and participation across age groups—from children to adults. Schools and sports communities frequently organize competitions and events, yet these efforts are often hindered by the lack of suitable infrastructure.

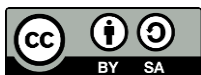
Certain sports such as futsal, badminton, and volleyball have shown considerable growth. However, the limitations in available facilities restrict this development from

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reaching its full potential. Research indicates that buildings designed without regard to local climatic conditions tend to be inefficient in energy use and thermal comfort. In tropical regions like Asahan Regency, high temperatures and humidity are major concerns. Poorly designed sports halls often rely heavily on air conditioning systems, which not only raise operational costs but also negatively impact the environment.

The most appropriate solution to this issue is to design sports facilities based on the principles of tropical architecture. This approach considers the unique characteristics of the tropical climate in all aspects of design—from layout and air circulation to the selection of building materials. Consequently, the resulting sports hall will not only be healthy and comfortable for users but also more energy-efficient and environmentally friendly.

Tropical Architecture is a design approach that adapts buildings to tropical climatic conditions, characterized by high temperatures, high humidity, and significant rainfall. The primary objective of tropical architecture is to achieve natural thermal comfort while minimizing reliance on mechanical cooling systems. According to Wahyudi and Anggriani (2022), tropical architecture is “a branch of architectural science that focuses on climate-responsive design based on the specific climatic and weather conditions at the building site, as well as its impact on the surrounding tropical environment.” Climate adaptation becomes a fundamental consideration in every aspect of its design process.

Tropical architecture plays a crucial role in achieving thermal comfort through the optimization of natural ventilation, daylighting, and spatial openness. Nurjani and Suardana (2024) emphasize that thermal comfort involves not only technical aspects but also the psychological well-being of building users. Meanwhile, Tri Harso Karyono explains that tropical architecture is an architectural response to challenges posed by tropical conditions, such as excessive heat, heavy rainfall, and high humidity. In his view, tropical buildings should be capable of creating comfortable indoor environments by effectively managing external climatic factors.

According to Dr. Ir. R.M. Sugiyatmo (as cited in Suryani, 2011), several criteria define buildings that apply the principles of tropical architecture:

2. Theoretical Review

Thermal, Visual, and Acoustic Comfort. One of the key goals of tropical architectural design is to provide thermal, visual, and acoustic comfort. Buildings should accommodate user activities despite the various climatic challenges typical of tropical regions. Thermal comfort includes maintaining clean air quality and temperatures that are neither excessively hot nor cold. Acoustic comfort is essential to ensure that building activities are not disrupted by noise, while visual comfort—adequate lighting—is critical to maintaining eye health (Karyono, 1999). To achieve this level of thermal performance, several key design elements must be carefully considered, such as:

a. Building Orientation

Building orientation significantly influences user comfort in relation to the sun's path. An optimal orientation is along the north-south axis, as this positioning minimizes direct exposure to the intense heat of the rising and setting sun. East-facing façades receive unpleasant thermal radiation between 09:00 and 11:00, while west-facing façades experience maximum solar heat between 13:00 and 15:00. Solar radiation directly affects the thermal performance of a building and can cause discomfort due to heat and glare. Orientation must also consider prevailing wind directions to maintain stable natural ventilation within the building (Nuraini, 2024). Wind direction has a considerable influence on the effectiveness of a building's orientation (Tyas et al., 2015).

b. Provision of Green Open Spaces

The extensive use of materials such as concrete or asphalt in outdoor areas should be minimized, as these materials absorb and retain heat, thereby increasing ambient temperatures and reducing indoor thermal comfort. Green open spaces are essential in tropical climates to reduce the surrounding temperature, absorb rainwater during wet seasons, and mitigate street noise (Nuraini, 2019). In addition to producing oxygen (O₂), trees can absorb carbon dioxide (CO₂), sulfur dioxide (SO₂), and heavy metal oxides from the air and water. During the daytime, solar radiation is absorbed by vegetation for the process of photosynthesis (Babo et al., 2017; Aziizah et al, 2024).

c. Material Selection

The principles of tropical architecture emphasize the use of locally sourced natural materials that are durable, have appropriate thermal absorption properties, and are well-suited to tropical climates (Nuraini, 2024). For instance, wood and lightweight steel are commonly used for structural frames and roofing systems (Nuraini, 2019; Nuraini, 2024). Aluminum is employed for window and door frames due to its ability to reduce heat transfer and noise. Bricks, which are fire-resistant and capable of withstanding high compressive forces, are used as wall materials. Additionally, light-colored, smooth-textured surfaces are recommended for reflecting sunlight effectively, while dark-colored, rough-textured surfaces are beneficial for reducing solar radiation penetration (Susilowati & Wahyudi, 2014).

2. Air Circulation

In the principles of tropical architecture, air circulation must be optimized through various cross-ventilation systems. The form and spatial arrangement of building masses on the site significantly influence wind flow into the building. Wind generally moves from areas of high pressure to areas of low pressure, which directly affects the positioning of buildings in relation to airflow patterns across the site. Therefore, buildings should be designed with as many openings as possible to allow continuous airflow, creating a cooling effect and enhancing indoor thermal comfort (Prianto et al., 2018).

3. Natural Daylighting

Tropical buildings require ample openings such as windows to facilitate the entry of sunlight during the daytime. The use of natural daylight as a lighting source contributes to significant energy savings by reducing dependence on artificial lighting (Aziizah et al, 2024; Prayoga et al, 2022). In addition to windows, skylights—roof-mounted openings—also allow sunlight to enter interior spaces effectively. The combination of windows and skylights helps reduce the building's reliance on electrical lighting during the day (Communications et al., 2020).

4. Protection from Solar Radiation and Heavy Rainfall

Exposure to direct sunlight often increases indoor air temperatures, which can lead to discomfort. To mitigate this, architectural elements such as **secondary skins** and **overhangs** can be utilized. A secondary skin refers to an outermost architectural layer that functions as a façade, positioned at a distance from the main building envelope to create a ventilated cavity that promotes airflow. Overhangs, particularly those with wide horizontal projections, are essential in tropical architecture as they effectively control the angle of solar penetration and prevent rainwater from entering indoor spaces. This helps protect interior furnishings and surfaces from moisture-related damage (Hadirman, 2012).

The implementation of a tropical architectural approach in the design of the sports facility in Asahan Regency is expected to produce a building that meets the standards of thermal comfort and energy efficiency, while also supporting the community's pursuit of a healthy lifestyle. Moreover, the facility is envisioned to serve as a central hub for athletic activities in Asahan, providing optimal training spaces to enhance athletes' performance. This sports facility is also intended to serve as a model for the development of other public buildings that emphasize sustainability and climate-responsive design, thereby contributing to the overall improvement of quality of life in Asahan Regency.

Design Problem

Based on the background described earlier, the main design problem addressed in this study is how to design a sports facility in Asahan Regency that optimally meets the needs of both the community and local athletes. Additionally, the problem concerns how to effectively apply the principles of tropical architecture in the facility's design to ensure comfort, energy efficiency, and environmental sustainability.

Objective

The objective of this design project is to develop a sports facility in Asahan Regency that not only fulfills the community's need for adequate sports infrastructure but also integrates sustainable architectural principles. The goal is to create a facility that serves as an appropriate and long-term solution to the challenges faced by the residents of Asahan Regency.

3. Research Methodology

1. Design Process

This study adopts a qualitative research approach, presenting findings derived from interviews and on-site observations, supported by data collection and analytical techniques (Yin, 2000 in Permana et al, 2023). The data collection process is categorized into two components: **Design Data Instruments** and **Site Data Collection**, both of which complement each other to form a comprehensive planning foundation (Moleong, 2000 in Alfyyah et al, 2023).

- **Design Data Instruments**
This stage involves the use of supporting tools to gather necessary information for the design process, including notebooks, cameras, laptops/computers, and measuring instruments.
- **Site Data Collection**
Site data were obtained through field surveys and literature reviews.

Following the data collection, the **analysis method** applied to the design of the sports hall in Kisaran, Asahan Regency—using a tropical architecture approach—was developed based on the identified design problems, project objectives, and site conditions. The design process involves qualitative research, identification of issues such as the lack of public interest in sports and the limited availability of adequate facilities (Nuraini, 2010 in Samudro et al, 2025; Syahputra et al, 2022). The designer conducted a comparative analysis by tracing and reviewing similar designs, including academic student projects, and comparing them with the official design standards for sports facilities issued by the government (Yin, 200 in Sitompul and Nuraini, 2024; Laia et al, 2024)

To generate a design solution that is both innovative and distinct from existing precedents, a thematic study was also conducted. This involved an in-depth exploration of design precedents related to **tropical architecture**, which served as the conceptual basis for the proposed solution. This process is illustrated in Figure 5.

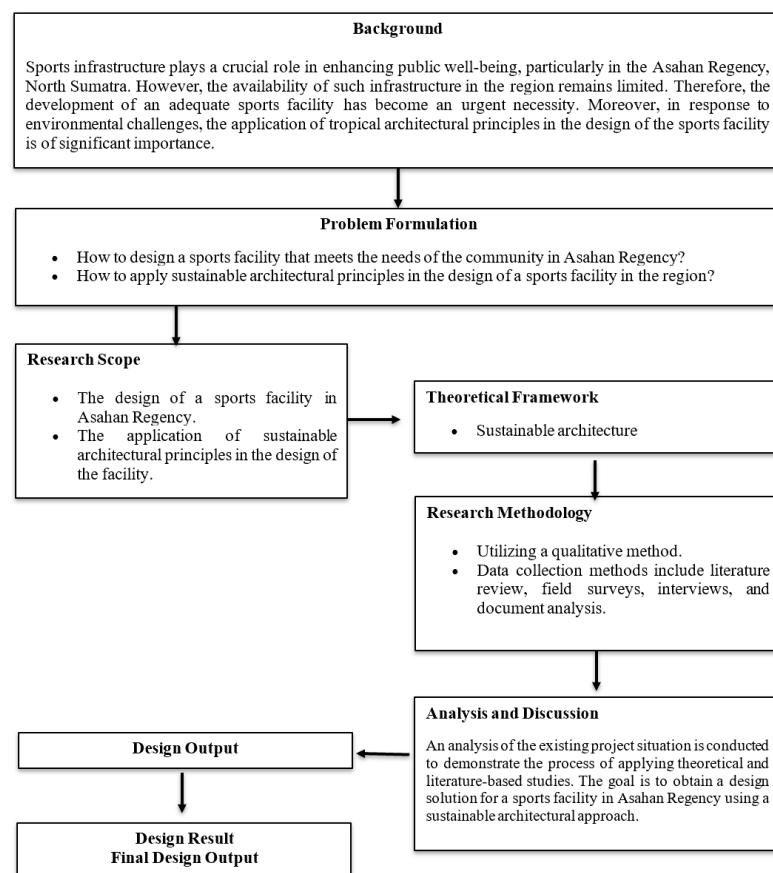


Figure 5. Design Process (Conceptual Framework)
(Source: Author's Analysis, 2025)

4. Results and Discussion

Site Analysis

The design of the Sports Hall in Asahan Regency, employing a Tropical Architecture approach, is situated in the city of Kisaran, Asahan Regency, North Sumatra. Specifically, the site is located on Abdi Setia Bakti Street, West Kisaran District, Asahan.

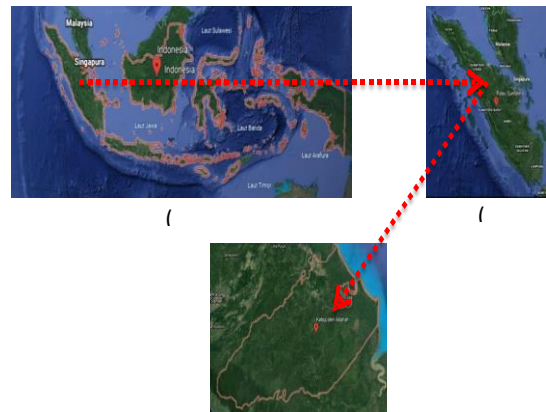


Figure 1. (1) Map of Indonesia, (2) Map of Sumatra, (3) Map of Asahan Region
Source: Google Earth, 2024

The site is located on Abdi Setia Bakti Street, covering an area of approximately 41,000 m², situated in West Kisaran District, Asahan Regency. It is strategically positioned near the government center, the city center of Kisaran, Kisaran Terminal, and the Trans-Sumatra Highway.



Figure 3. Site Location
(Source: Constructed by the author, 2024)

With stable soil conditions and a total land area of 10,546 square meters, the Building Coverage Ratio (BCR) is 70%, which means approximately 7,382 square meters of the site can be utilized for building construction. In addition, a minimum of 10% Green Open Space Ratio (GOSR) must be preserved for green areas. The advantages of this site include:

The advantages of the site include:

Proximity to the North Sumatra Trans-Regional Road, facilitating easy access for visitors coming from outside the area; The site is adjacent to a wide road (approximately 21 meters), allowing easy access for large vehicles; Close to a hospital, which is beneficial in case of emergencies.

The disadvantage of the site:

At certain times, the road in front of the site is used for illegal street racing.

Site Analysis

1. Building Setback Line (BSL) Analysis

On the north and west sides, the site is bordered by oil palm plantation land. On the south side, the site is bordered by Abdi Setia Bakti Street, which has a width of 21 meters. The Building Setback Line (BSL) is 11.5 meters. On the east side, the site is bordered by Komplek Ruko Terminal Street, which has a width of 9 meters.

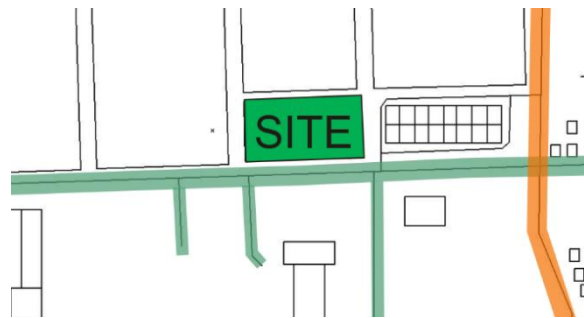


Figure 2: Street View of the Site

2. Entrance Analysis

The site design provides an entrance on the right side of the site and an exit on the left side.

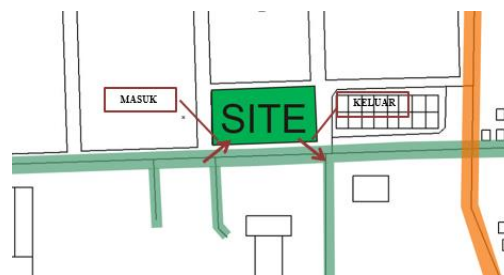


Figure 3: View of Entrance and Exit Access on the Site

3. Pedestrian Analysis

There is currently no pedestrian pathway at the site; therefore, the design includes the addition of pedestrian walkways along the front and surrounding areas of the site.

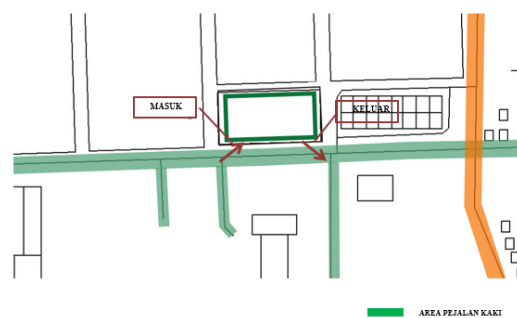


Figure 4. Pedestrian Area Illustration

4. Sun Path Analysis

Response:

The design incorporates multiple openings on the eastern side to maximize morning sunlight, while minimizing openings on the western side due to excessive heat and glare from the afternoon sun.



Figure 5. Sun Path Analysis Illustration

5. Noise and Wind Direction Analysis

Noise Analysis

- To the north and west, the site is bordered by oil palm plantations, which results in low noise levels.
- To the south, the site is adjacent to Abdi Setia Bakti Street, which has high noise levels due to traffic.
- To the east, the site borders the Terminal Shop Complex Road, with moderate noise levels.

Wind Direction Analysis

- During the day, the prevailing wind comes from the west.
- At night, it shifts and comes from the east.

Design

Vegetation is provided along the southern boundary to minimize noise generated by motor vehicles. Openings are created in the direction of prevailing winds to enhance natural ventilation, reduce energy consumption, and create a cooler indoor environment.

Response:



Figure 6. Noise and Wind Direction Analysis Illustration

6. Vegetation Analysis

Tree Types Identified:

- Mature oil palm trees located on the eastern, southern, and western sides of the site
- Angsana trees located at the front of the site (southern side), specifically along Abdi Setia Bakti Street

Design Response:

The existing oil palm trees on the site will be removed due to their age and replaced with alternative tree species that can improve air quality, enhance site aesthetics, and support water absorption in the area.

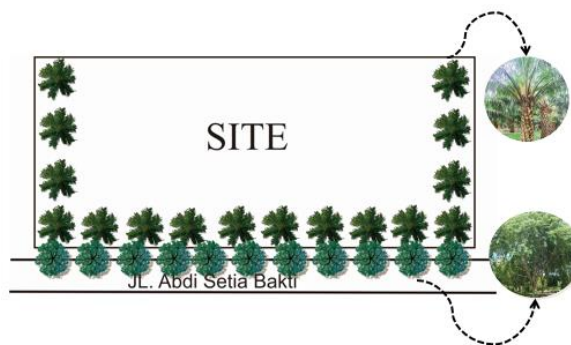


Figure 7. Vegetation Analysis Illustration

Spatial Program Overview

Based on the spatial program, the proposed sports facility will include the following components:

Table 1: Analysis of Space Requirements for Management

Type of Activity	Activity	Space Requirement
Management	Director Administration	Parking
	Staff Coordination	Labby
	Guest Reception	Director's Office
	Data Storage	Deputy Director's Office
	Meetings	Secretary's Office
	Archiving	Head of Division Office
	Sanitation	Administrative Office
	Mechanical & Electrical (ME)	Public Relations Office
		Archive Room
		Meeting Room
		Information Room
		Guest Room
		Storage
		Restroom Type 1
	Restroom Type 2	

Table 2: Analysis of Space Requirements for Support and Sports Facilities

Penunjang	Activity	Space Requirement
	Medical	Physiotherapy Room
	Meetings	Sensor Integration Therapy Room
	Reading	Radiology Room
	Storage	Art Gallery

	Waiting	Library
	Sanitation	Mosque
		Waiting Room
		Restroom Type 1
		Restroom Type 1
Sports	Training	Indoor Sports Hall
	Learning	Athlete Changing Room
	Storage	Coach Changing Room
	Rest	Classroom
	Changing	Tribune
	Sanitation	Gym Room
		Jogging Track
		Equipment Storage
		Restroom Type 1
		Restroom Type 2

Table 3: Analysis of Service Space Requirements

Service	Activity	Space Requirement
	Meal Accommodation	Dining Room
	Staff	Kitchen
	Cleaning Staff	Food Court
	Transportation	Laundry Room
	Sanitation	Ironing Room
		Office Boy / Staff Room
		Cleaning Service Room
		Bus Driver Room
		Electricity Room (PLN)
		Generator Room
		Pump Room
		CCTV Operator Room
		General Storage
		Garage
		Security Post
		Restroom Type 1
		Restroom Type 2

Activity Pattern Analysis1. **Activity Pattern of the Management Team**

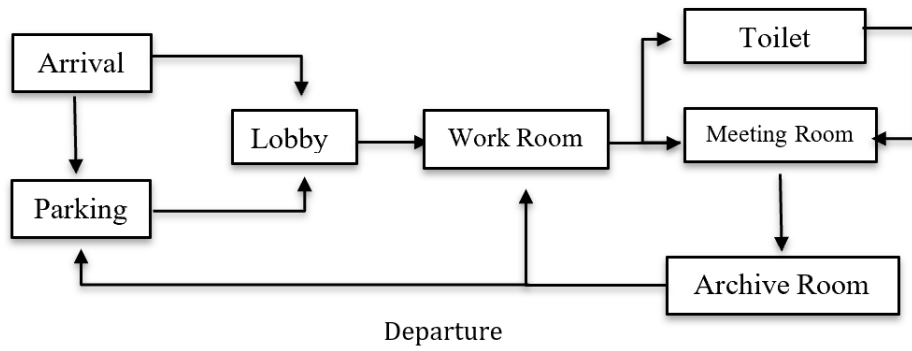


Figure 8: Activity Analysis Diagram of the Management Team.

2. Activity Pattern of Coaches and Athletes

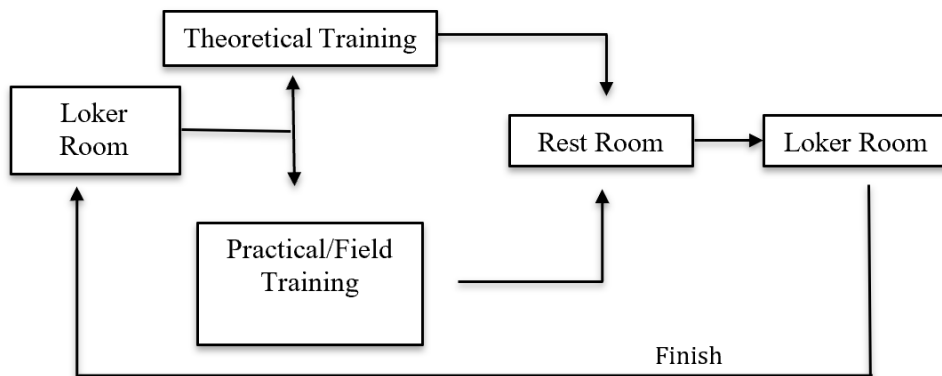


Figure 9: Activity Analysis Diagram of Coaches and Athletes.

3. Activity Pattern of Staff

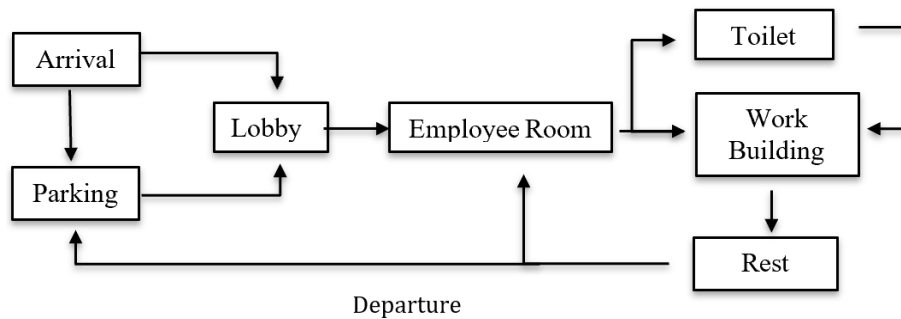


Figure 10: Activity Analysis Diagram of Staff.

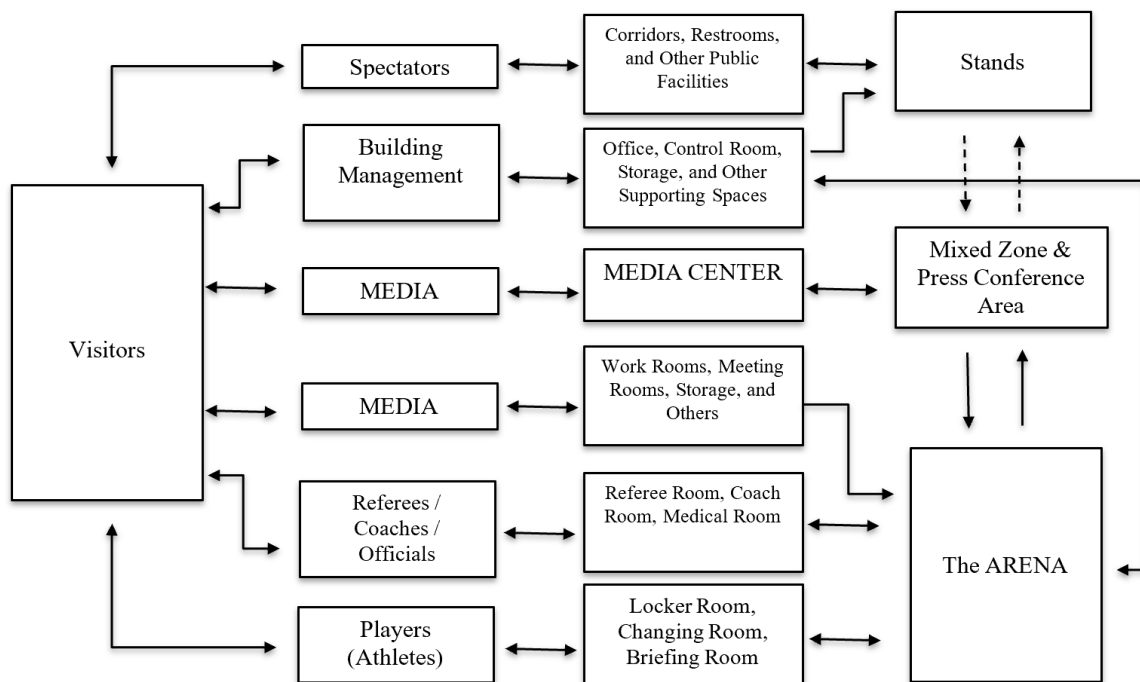


Figure 11: Circulation Diagram of Players, Coaches/Officials, Media, Spectators, Match Organizers, and Building Managers (According to the Ministry of Youth and Sports Regulation – Standard for Sports Halls)

Zoning

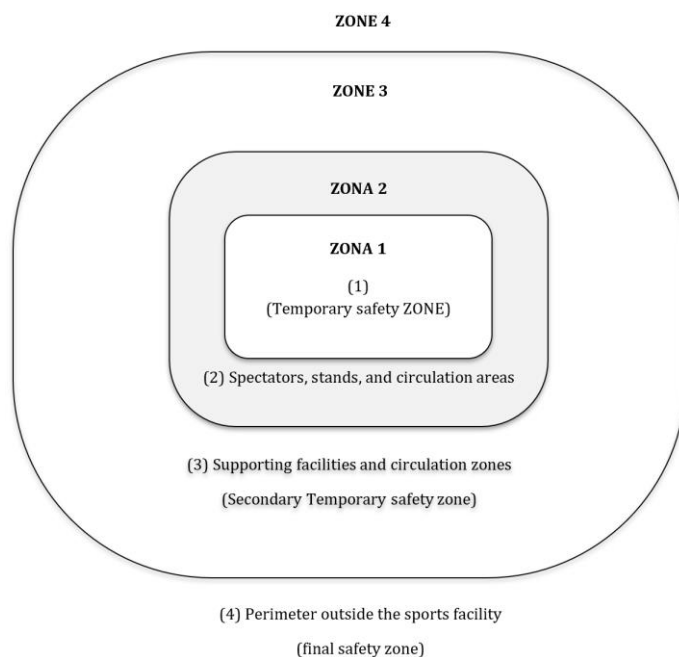


Figure 12: Safety Zoning Diagram of the Sports Facility (Source: Ministry of Youth and Sports Regulation – Sports Hall Standards)

Zone 1

(Arena and Temporary Security Area)

This zone represents the main secured core of the sports facility and serves the following functions:

- The venue for sports activities;
- Access and exit routes for the arena; and
- A separator between the spectator area and athlete circulation.

Zone 2

(Spectator Stands and Circulation)

This zone ensures the security and orderliness of the spectator facilities within the sports building, functioning to:

- Maintain spectator discipline;
- Organize circulation flow; and
- Provide internal evacuation routes within the building.

Zone 3 *(Supporting Activity Facilities)*

This zone secures all supporting facilities located around the perimeter of the sports building, and is intended to:

- Provide direct access to the exterior;
- Manage circulation flow; and
- Facilitate emergency evacuation when needed.

Zone 4 *(Exterior of the Building – Final Safety Zone)*

This zone comprises the outermost secured area surrounding the building (perimeter zone), and functions to:

- Serve as an emergency-safe zone;
- Accommodate external circulation and visitor screening; and
- Act as the final evacuation zone in emergencies before transferring to external safety areas.

Tropical Architectural Design Concept

The sports hall in Asahan Regency is designed based on the principles of tropical architecture, which aims to address the challenges posed by tropical climates. Tropical climates are typically found along the equator and are characterized by high temperatures, humidity, and rainfall.

The primary objective of this architectural approach is to create buildings that can adapt to tropical environmental conditions, ensuring comfort and protection for occupants. In theory, tropical architecture should operate passively, meaning it can automatically respond to climate conditions through design strategies and material selection.

Karyono (1996) states that tropical architecture is a design concept aimed at resolving the problems caused by hot and humid tropical climates. The application of tropical architectural principles may vary depending on local context and cultural background. According to Zurnalis (2017), issues such as year-round solar exposure, seasonal heavy rainfall, and low wind velocity can be addressed through the effective implementation of tropical architectural strategies.

Asahan Regency is characterized by an extensive marine area with a coastline of approximately 57.68 kilometers. A significant portion of the population residing in coastal areas work as fishermen. In the fisheries sector, production consists of both wild catches and aquaculture activities conducted by local fish farmers.

The livelihoods of the local community are derived from fishing activities and aquaculture, particularly the cultivation of fish and shellfish. Asahan is known as the "City of Shellfish" due to the significant contribution of shellfish to its marine resource potential.

The conceptual foundation of the tropical architectural design emphasizes harmony with the natural environment. The core principles of this architectural approach include the use of high and sloped roofs for optimal ventilation, the maximization of natural lighting, and the application of local materials that are durable against tropical weather conditions.

In the context of the sports hall in Asahan Regency, the implementation of tropical architecture aims to create a comfortable, energy-efficient, and sustainable building, while also reflecting the local identity. The shell form was chosen as the conceptual basis for the building's shape, inspired by Asahan's identity as the "City of Shellfish." This form serves not only as a regional symbol but also as a functional design element capable of reducing heat and humidity typical of tropical climates. Additionally, the shell structure offers strength and stability.

The design is inspired by the marine potential of Asahan Regency, which is rich in shellfish, and by the need for architecture that can adapt to tropical climate conditions. The transformation process of the shell form is illustrated in Figure 7



Figure 7. Form Transformation Process Structural System

Shell Structure

According to Joedicke (1963), a shell structure is a plate that curves in one or more directions, with a thickness much smaller than its span. Schodeck (1998) describes a shell as a rigid, thin, three-dimensional structural form with a curved surface. Consistent with these definitions, Ishar (1995) emphasizes that a shell is thin and curved; therefore, thin flat structures or thick curved structures cannot be classified as shells. The term "shell" is also referred to as "shell skin" by Salvadori and Levy (1986).

Sports Facility Design with a Tropical Architecture Approach

The sports facility in Asahan Regency is located on Abdi Setia Bakti Street, West Kisaran, North Sumatra, on stable ground with a total land area of 10,546 square meters. The Building Coverage Ratio (BCR) is 70%, allowing approximately 7,382 square meters to be used for construction. In addition, a minimum Green Open Space Ratio (GOSR) of 10% must be maintained for green areas.

In the design of this sports facility, a tropical architectural approach is applied to meet the community's needs for environmentally friendly and sustainable sports infrastructure. The site plan of the sports facility using a tropical architecture approach is shown in **Figure 8**.



Figure 8. Sports Facility Site Plan

The sports facility is situated in an area surrounded by primary circulation routes. Since there are no existing pedestrian pathways on the site, the design incorporates new pedestrian zones at the front and around the perimeter to enhance accessibility. This ensures convenient and strategic entry and exit points, as well as safe and comfortable pedestrian movement.

An effective circulation pattern, along with proper noise analysis and wind direction considerations, contributes to creating an optimal environment for sports activities. As a result, the facility can function effectively and safely for its users. The layout of utility lines has also been properly planned and meets standard requirements.

In designing the Sports Facility in Asahan Regency, the building orientation and opening design are optimized for comfort and energy efficiency. Numerous openings are placed on the east side to capture the morning sunlight, while openings on the west side are minimized to reduce exposure to intense direct sunlight, as shown in **Figure 9**.



Figure 9. Sun Path Analysis

This sports facility is also intended to serve as a model for future public infrastructure developments that prioritize sustainability and adaptation to the local climate, thereby contributing to an improved quality of life for the residents of Asahan Regency. The floor plan of the sports facility is presented in **Figure 10**.

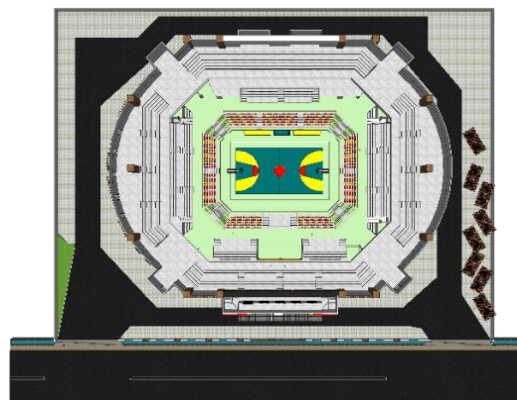


Figure 10. Floor Plan of the Sports Facility

The main structure of the Sports Facility in Asahan Regency, designed with a Tropical Architecture approach, utilizes a combination of long-span structural systems and reinforced concrete to create a dynamic and modern impression. The roof structure employs a long-span shell system supported by a strong and stable space frame. The roofing material is made of zincalume, chosen for its corrosion resistance and lightweight properties.

This design is envisioned to become a new landmark in Asahan Regency while fulfilling the community's need for an adequate and sustainable sports facility, as illustrated in **Figure 11**.

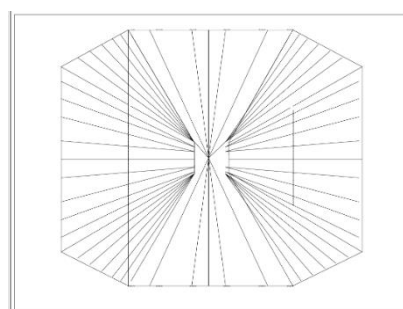


Figure 11. Roof Plan

The selected roof structure utilizes a space frame system with interconnecting elements. This structure is easy to assemble, shape, and disassemble, thus expediting the construction process. The space frame system is highly suitable for buildings with large spans that do not require interior columns, thereby creating more open and flexible interior spaces.

Additionally, the space frame construction system is lightweight and adaptable to various roof forms. With a relatively long lifespan of approximately 50–100 years and high aesthetic value, it is an ideal choice for large-span buildings with unique architectural designs. The interior atmosphere of the Sports Facility in Asahan Regency, designed with a Tropical Architecture approach, is shown in **Figure 12**.

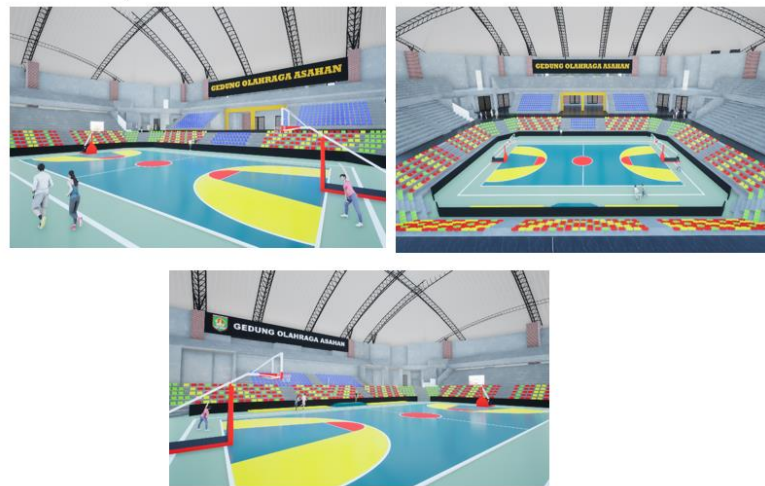


Figure 12. Interior of the Sports Facility

The exterior environment of the Sports Facility in Asahan Regency, designed with a Tropical Architecture approach, is shown in **Figure 13**.





Figure 13. Exterior of the Sports Hall (2)

5. Conclusion

In response to current issues, this study explores how to design a sports hall that can revive public interest in sports and how to adapt such a facility to a tropical climate. The aim is to encourage community engagement in sports by providing a well-designed facility that not only supports recreational activities but also serves as a platform for individuals aspiring to become professional athletes. The proposed design of the sports hall also has the potential to become a new icon for the Asahan community. The design process employed a qualitative research method, incorporating findings from interviews and on-site observations. The sports stadium is expected to become a key attraction for Subang Regency, fulfilling the community's need for sports infrastructure and contributing to the economic development of Asahan Regency.

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