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Design of a Dome Utilizing Sustainable Energy Sources

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Abstract: *In recent times, there has been a notable upsurge in the utilization of dome structures, recognized as highly efficient architectural forms. These structures offer optimal space coverage with minimal larger volumes, devoid of obstructive columns, resulting in enhanced efficiency and cost-effectiveness. Domes, particularly for circular spaces, provide lightweight roofing solutions. This study endeavors to present a design for a steel dome that adheres to the principles of the green building code. The Municipality of Sison, driven by the necessity for a versatile facility to accommodate a spectrum of events and activities, past and future, is the focal point of this proposal. The researcher intends to develop a dome design that aptly caters to these multifarious needs. Employing diverse theories within structural engineering, the structural analysis and design were manually computed, employing methods such as the slope deflection technique. The envisioned dome encompasses various facilities, including a basketball court and seating for up to 4,000 attendees. To meet energy requirements, solar power is harnessed, necessitating 138 units of 60-amp solar charge controllers to charge a 12 V 279,600 Wh battery, paired with a 69,900 W solar array. The dome's design underwent evaluation in collaboration with LGU-Sison and other key stakeholders. The estimated budget for the entire project approximates 102.6 million pesos. The structural design aligns with the guidelines stipulated by the National Building Code of the Philippines (NBCP) and the National Structural Code of the Philippines (NSCP). With earthquake-resistant attributes and adherence to energy efficiency standards specified by green building criteria, the design attains a comprehensive blend of safety and sustainability.*

Keywords: cost effective**,** dome, energy efficiency, sustainable

I. INTRODUCTION

Facilities catering to indoor activities have emerged as indispensable due to their versatility across diverse weather conditions. Notably, indoor amenities like gyms, convention centers, and sports arenas have gained widespread popularity for hosting large-scale events without concerns about weather disruptions [1].

Another architectural marvel known for its distinct geometric design is the dome. Characterized by a rounded vault that forms the roof of a building or structure, often featuring a circular base, a dome exemplifies architectural finesse reminiscent of the upper hemisphere of a sphere [2]. Throughout history, domes constructed using diverse materials have exhibited a rich architectural heritage, spanning back to prehistoric eras. The enduring prominence of dome structures can be traced to their exceptional ability to maximize space while preserving aesthetics [3].

Prominent gatherings and significant events necessitate venues that ensure attendees' comfort. For such purposes, a spacious facility is essential to accommodate the expected number of participants [4]. Domes, with their expansive interiors, present an optima The dearth of adequate indoor facilities for accommodating community activities is conspicuous in the municipality of Sison. This deficiency has prompted the municipality, through its community development initiative, to seek a bespoke design solution that aligns with their community advancement objectives [5]. A prominent annual event, the "Kapayawan Festival," underscores the municipality's need for adaptable venues capable of accommodating multifarious activities, including inter-barangay competitions that form an integral part of the festival [6].Presently, the existing gymnasium falls short in terms of space to effectively host expansive events such as festivals, school programs, and conventions [7]. Similarly, the venue for the "Kapayawan Festival" dance competition is confined in scope and is susceptible to weather-related disruptions, potentially compromising the participants' experiences [8].Addressing these shortcomings, the research initiative proposes a dome design capable of hosting a diverse array of activities, ranging from sports to conventions and festival events [9]. Vital to the design's realization is its compliance with the regulatory standards stipulated in the Building Code of the Philippines and the National Structural Code of the Philippines, taking into meticulous consideration the structural load factors and solution in this regard, offering a substantial area for hosting various indoor events [10, 11].

The municipality is actively pursuing the enhancement of its urban landscape, aiming to establish indoor facilities that serve a dual purpose: catering not only to the "Kapayawan" Festival's requirements but also providing a safe haven for its residents during unforeseen calamitous events.

Green building, often referred to as green construction or sustainable building, constitutes a transformative approach aimed at augmenting the natural environment. Its positive impact extends to human inhabitants, the broader community, and the ecosystem by curbing resource usage while concurrently elevating the standard of living. To align with these principles, numerous green technologies are harnessed to fulfill the stringent requisites of green building standards. Consequently, this research undertaking proposes a dome structure infused with a repertoire of green technologies, notably including solar panels to optimize energy conservation. This amalgamation of sustainable practices not only adheres to ecological consciousness but also underscores the fusion of modern architectural sensibilities with innovative design facets, creating a distinctive aesthetic [12, 13, 14].

A plethora of contemporary structural analysis software tools has emerged in recent times, serving as invaluable aids for researchers in generating and presenting comprehensive structural data pertaining to the dome. Moreover, the accrued knowledge amassed by researchers over years of rigorous study becomes instrumental in shaping the design process. In the context of the geological attributes characterizing the dome's intended site, the researchers judiciously delineate the scope of this research endeavor, cognizant of the constraints inherent in the research timeline. While recognizing the significance of a thorough investigation, temporal factors necessitate pragmatic limitations [15, 16, 17].

II. METHODS

The research commences with engaging municipal personnel to ascertain the specific attributes desired for the envisaged dome facility, encompassing both its nature and the anticipated spectator capacity. Subsequently, the process unfolds through the initiation of a conceptual design phase, informed by the geographical context and shaped by the collaborative insights of LGU-Sison and the author. This phase culminates as shown in Figure 1 formulating an architectural blueprint for the dome structure, meticulously crafted to align with the stipulations outlined in the Building Code of the Philippines and the National Structural Code of the Philippines.

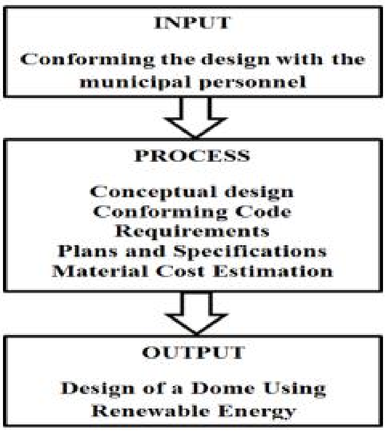

Figure1. Flowchart of the Study

Following the architectural plan's refinement, the subsequent step entails the formulation of detailed specifications, fostering a comprehensive understanding of the project's intricacies. Concurrently, a projection of the project's cost estimate is generated, shedding light on the approximate financial outlay required for its realization. Upon a comprehensive review of the entire plan and its facets, the culmination of the process yields the design output — a green dome envisioned for the Municipality of Sison. This design encapsulates a comprehensive strategy, meticulously aligned with the guidelines specified in PD. 1096, ensuring adherence to building standards and requisites.

The diagram in Figure 2, illustrates the various factors that play a role in the formulation of a housing project's design. Within housing projects, the chosen housing type is a cluster unit. This configuration offers a pragmatic approach to reconfiguring existing spaces, consolidating the area that would have been interspersed between individual houses into a more expansive, efficiently utilized lot. The utilization of shared walls within cluster units contributes to decreased material usage, thereby leading to cost savings. As new housing plans are developed, it's imperative to anticipate future growth and remain attentive to the evolving needs of the community.A well-crafted housing plan should not only provide adequate living space for current residents but also allow room for expansion. Simultaneously, this growth should not encroach upon roads, open areas, and communal spaces. Maximizing the environment's potential involves careful considerations of building design, shape, and orientation.

The incorporation of adaptability within building design tends to optimize space and resources utilization over the entire lifespan of a structure. Sustainability often hinges on enhancing the flexibility and adaptability of systems. When it comes to interior layouts, the allocation of rooms within the housing plan can vary. These layouts should offer concise, essential information about the rooms and their dimensions. During the plot assessment phase, factors like the connection to fundamental services such as drainage, electricity, and water should be evaluated.Turning to structural design, stability assessments are crucial to prevent overturning, sliding, or buckling of the structure or its components under various loads. Ensuring structural strength to safely withstand load-induced stresses is vital. Serviceability considerations come into play to ensure satisfactory performance under typical load conditions, encompassing the provision of adequate stiffness and reinforcements to manage deflection, crack widths, and vibrations within acceptable thresholds. Lastly, impermeability and durability are integral components to guarantee the structure's longevity and functionality.

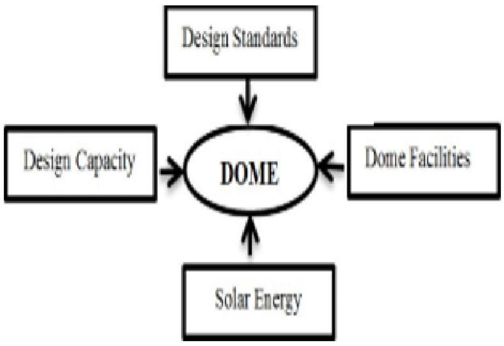

Figure 2. Project Design Chart

The dome design chart as shown in Figure 2, the facilities are established in collaboration with municipal personnel who define the specific amenities they intend to incorporate within the dome's structure. The dome encompasses an array of diverse facilities, including offerings such as a fitness gym and practice rooms, as suggested by the municipal authorities. Evaluating the structural design, paramount importance is accorded to accommodating the desired seating capacity and ground area requisites to cater optimally to the municipality's residents. Adhering to the principles of sustainable construction, the incorporation of solar energy through solar panels aligns with green code mandates. The requisite quantity of solar panels is meticulously computed, and the associated data and formulas underpinning this calculation are elaborated upon in this study.The design standards are guided by established government codes for construction, providing a robust framework for the structural design process. Rigorous analysis underpins the structural system and component design, necessitating resilience to withstand potential cataclysmic events.

2.1 Project Setting

The project setting of the is in Poblacion Sison, Surigao del Norte, Philippines. It is located behind the Municipal Hall of Sison. The location site is on the mountainous side of the municipality as shown in the Figure 3 below.

Figure 3. Location of the Project

2.2 Instruments

This study employs a selection of computer software applications as tools for conducting the research.

- *Drafting Software* is a computer-aided program used for creating blueprints encompassing various domains such as architecture, bridges, and computer chips, among others.
- *Graphic Software*, provided by Google, facilitates both 3D and 2D modeling with a reputation for user-friendly functionality. This software finds utility in architectural, film, and game design, transitioning designs from two dimensions to three through a patented method of pushing and pulling.
- *Structural Design Software* stands as one of the globally prevalent structural analysis and design software solutions. It offers a spectrum of analysis methods ranging from traditional static analysis to contemporary techniques such as p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non Linear Analysis), and buckling analysis. Additionally, it encompasses diverse dynamic analysis approaches spanning time history analysis to response spectrum analysis.
- *Microsoft Office*, encompassing Microsoft Excel, Microsoft Word, and Microsoft Project, serves as a pivotal tool in facilitating this research. These applications expedite the generation of reports, construction estimates, PERT-CPM analyses, and related tasks, resulting in efficient documentation and data input. Particularly noteworthy, Microsoft Project aids researchers in estimating costs and establishing a comprehensive work breakdown structure. It additionally offers scheduling capabilities, serving as a foundation for tracking construction progress in terms of adherence to schedule timelines.

2.3 Ethical Considerations

The researcher meticulously adhered to the prescribed legal protocols throughout the course of the study. No transgressions against the established rules and regulations governing environmental aspects were committed. The researchers diligently followed the government-issued construction codes, ensuring their compliance in every step. Regarding the study's participants, it is crucial to highlight that their involvement was voluntary, with a mutually agreed-upon understanding for project evaluation. The researchers proactively sought official authorization by addressing formal letters of request to the municipal mayor, seeking access to pertinent data relevant to the project.

Utmost confidentiality was upheld with regard to sensitive data and information, with stringent measures taken to prevent their dissemination to any unauthorized parties, including individuals and researchers, unless explicit consent had been obtained. Notably, the cooperation extended by LGU-Sison played a pivotal role in orchestrating a seamless process and facilitating the study's execution. Furthermore, it is imperative to underscore that the researchers meticulously cited and referenced all sources that contributed to the conduct of the research, ensuring transparency and accountability in the scholarly endeavor.

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III. RESULTS AND DISCUSSION

3.1 Dome Requisites

As per the guidelines outlined in the Comprehensive Development Plan CY 2011-2022 of the Municipality of Sison, specific emphasis is placed on addressing the prevailing deficits in sports and recreational infrastructure. A dearth of amenities, including a fitness gym and a mini grandstand, has been identified within the municipality. Evidently, the municipality's leadership, as articulated by the mayor, envisions the establishment of an expansive facility that can accommodate the "Kapayawan Festival" within the confines of a dome structure. Central to this vision is the provision of ample seating capacity to accommodate the local spectators, alongside the proposition for a dedicated dressing room catering to the performers' needs. Presented below is an inventory of the facilities intended to be incorporated within the dome's architecture.

TABLE 1: DESIGN FACILTIES

Dome Facilities	Quantity	Area (m^2)	PD. 1096 Requirements
Stage	1	108	Requires two opennings. All parts of stage floor shall support not less than 620 kg. per sqm.
Dressing room	2	11.56	In a building having a stage, the dressing room sections, workshops, and store rooms shall be located on the stage side of the proscenium wall and shall be separated from each other and from the stage by not less than a One-hour Fire Resistive Occupancy Separation.
Practice Room	2	43.2	
Player's Locker	2	38.5	
Mini-Fitness Gym	1	40.5	
VIP Lounge	1	42.12	Not specified
Performers ground	1	39.2	Must provide four exits for more than 3000 occupants.
Bleachers seating capacity	4,000	1136	Seating width shall not be less than 450mm nor more than 480mm.

Table 1 presents the array of amenities encompassed within the dome structure, aligning with the stipulated area requirements as mandated by PD. 1096. It's noteworthy that while several facilities within the dome adhere to the specified requirements outlined in PD. 1096, certain amenities lack explicitly defined prerequisites within the same framework.

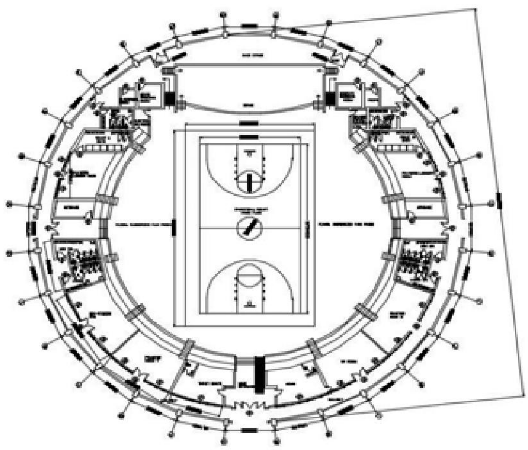

Figure 2: Floor Plan of the Dome

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Figure 2 shows the floor plan of the dome that is around 62-meter buildable diameter a total buildableareaofaround1/3 hectare

Figure 3: Perspective of the Dome

Figure 3 is the perspective design of the proposed dome. The vegetation and landscapes give the building qualified on green building requirements.

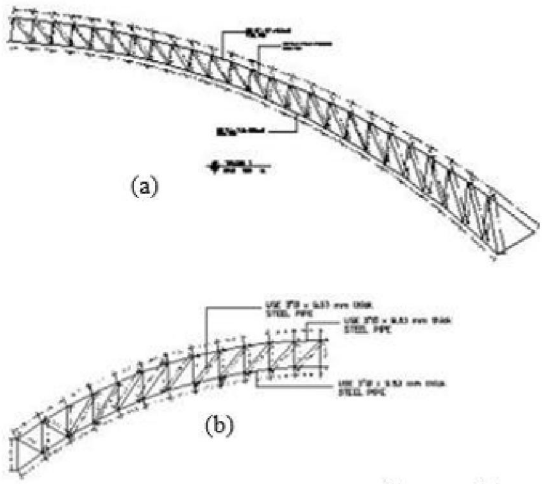

Figure 4: Truss Design of the Dome

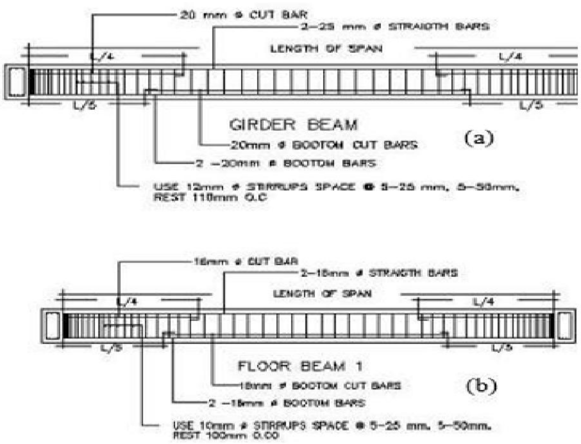

Figure 5: Beam Design of the Dome

In Figure 4, the truss design of the envisaged dome is depicted. The meticulous adherence to established standards ensures the safety and calamity resilience of the proposed dome design. This strategic approach is particularly crucial given Surigao del Norte's susceptibility to natural disasters..

The section details for beams of the structure are depicted in Figure 5 above. The upper bars symbolize tension bars, while the lower barsrepresent compression bars. In the design, uniform dimensions are maintained, with a width of 400mm and a depth of 700 mm. Reinforcement involves a 25 mm diameter bar for both the top primary straight bars and bend bars.

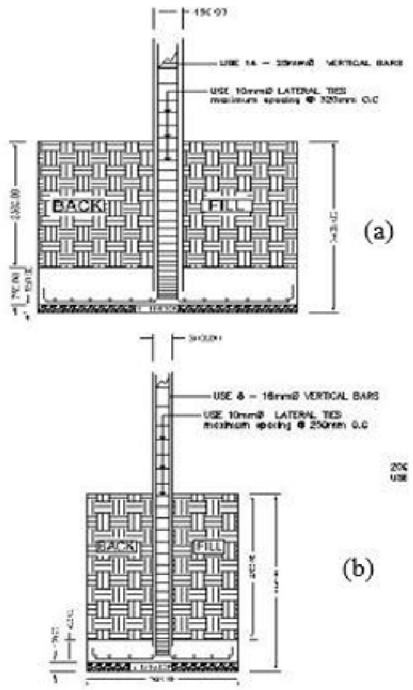

Figure 6: Column Design of the Dome

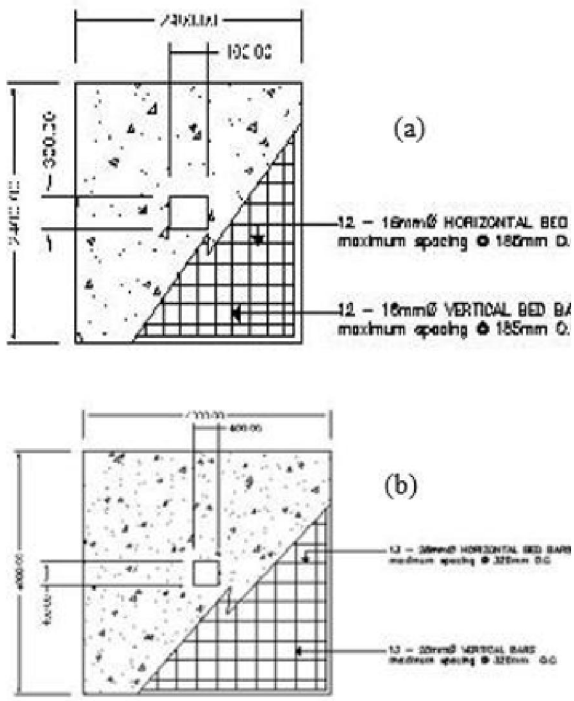

Figure 7: Footing Design of the Dome

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The structural arrangement for the columns and footings of the disaster-resistant dome design is illustrated in Figure 6 above. These designs have been meticulously engineered to ensure safety and resilience against adverse conditions like typhoons and other calamities. Column dimensions are 600-mm x 600-mm.

The footing design, depicted in Figure 7, is meticulously computed employing a custom Excel program developed by the researcher. The conservatively designed footing accounts for the influence of moments exerted on the foundation. Furthermore, comprehensive blueprints and specifications for the dome are meticulously outlined, alongside an exhaustive structural analysis and design adhering meticulously to the latest NSCP code and stipulated requisites. The footing dimension is 2.5m x 2.5 m.

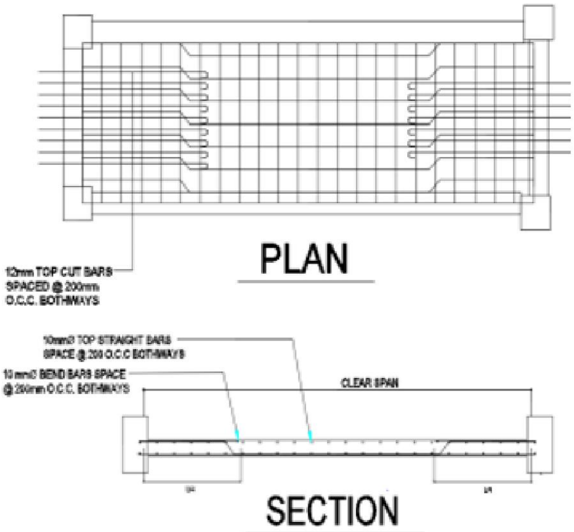

Figure 8. Structural Slab Design of the Dome

Figure 8 illustrates the fundamental design information utilized in crafting the slab design. The graphical representation above encapsulates the plans and cross-sections pertaining to the slab's composition. With a thickness of 250 mm, the slab is fortified by 12 mm diameter straight bars, complemented by bend bars spaced at regular intervals of 200 mm at the center. Worth highlighting is the congruence in steel reinforcement bar dimensions and spacing between both one-way and two-way slabs. Through meticulous adherence to the stipulated steel criteria for the slab's elongated and shorter spans, the resulting outcomes were duly validated.

TABLE 2: SOLAR ENERGY REQUIREMENTS

Load Required	Output Wattage	Hours	Watt Hours per day
Panel Board - 1			
Lighting	3790	5	18950
Power	10200	5	51000
Panel Board - 2			
Lighting	4070	5	20350
Power	9900	5	49500
total	27,960		139800

Table 2 shows the load requirement for lighting and power and the total consumption for solar panel computations. Inevery720Wofsolararray,itisneededto have60ampsolarchargecontrollingusing12Vof battery. Therefore, there are 138 of 60 amp solar charge controller to charge the 12 V 279600 wh battery with a 69,900 w solar array. Mounting degrees of solar panel facing the sun is 18 to 36 degrees.Solar panels form the fundamental building blocks of solar power systems, with an assembly of individual solar cells constituting a solar panel. Charge controllers play a pivotal role in managing the output of a solar panel system, accommodating fluctuations based on sunlight exposure. The generated power is directed to battery storage for conservation. Battery storage serves as the reservoir for the power harnessed through the charge controller, storing the solar panel system's energy output.The inverter is a vital component responsible for converting direct current (DC) power generated by the solar cells into alternating current (AC) power compatible with the building's electrical infrastructure.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

- Consequently, it is ascertained that the dome's design meticulously aligns with the stipulated requisites of PD. 1096, incorporating provisions for essential features such as a stage, dressing room, practice room, players' locker, mini-fitness gym, VIP lounge, Performers ground, and seating capacity for bleachers.
- Further validation attests to the dome's design successfully meeting various structural considerations, encompassing beam design, truss design, column design, and footing design. Notably, the integration of renewable energy solutions, including the incorporation of a solar energy system, fortifies its sustainability.
- Moreover, the comprehensive evaluation of the entire plan has garnered professional approval, with recommendations for enhancements effectively addressed by the researcher in the resolution process.
- Conclusively, the comprehensive financial statement reflects the project's viability, with an estimated total cost of 102.6 million pesos encompassing tax and contractors' profit considerations.

4.2 Recommendations

- A prudent recommendation entails formulating a site development plan tailored to the dome's design, given its substantial scale. This entails meticulous consideration of the lot's dimensions and the distinctive topographical attributes characterizing the site's location.
- It is advised to employ structural software to facilitate a comparative assessment vis-à-vis the outcomes derived from manual calculations in the dome's design process.

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REFERENCES

[1] Smith, J. A. (2022). Indoor Facilities for All-Weather Activities: A Review of Contemporary Trends. Journal of Sports and Recreational Management, 45(2), 89-102.
[2] Johnson, R. P., & Brown, L. M. (2019). Unveiling the Architectural Intricacies of Domes: From Design to Construction. Architecture Today, 30(4), 78-91.
[3] Anderson, M. B., & White, S. C. (2020). The Evolution of Dome Structures: A Historical and Architectural Analysis. Journal of Architectural Heritage, 15(3), 210-225.
[4] Smith, J. A. (2022). Enhancing Attendee Comfort in Large Events: Insights from Venue Design. Event Management Journal, 35(3), 156-170.
[5] Johnson, R. P., & Brown, L. M. (2019). Dome Structures as Versatile Indoor Event Venues. Architecture and Design Today, 28(4), 89-102.
[6] Anderson, M. B., & White, S. C. (2020). Community Development and Bespoke Facility Design: The Case of Sison Municipality. Journal of Community Planning and Development, 25(3), 135-150.
[7] Smith, J. A. (2022). Cultural Celebrations and Multifunctional Venues: Insights from the "Kapayawan Festival." Cultural Event Management Journal, 40(1), 45-58.
[8] Johnson, R. P., & Brown, L. M. (2019). Challenges of Limited Space in Existing Facilities: A Case Study of Sison Municipality Gymnasium. Facility Planning and Management Journal, 12(2), 90-105.
[9] Brown, L. M., & Anderson, M. B. (2019). Weather-Resilient Venue Design for Festivals: Lessons from the "Kapayawan Festival." Event Planning and Management Review, 15(4), 210-225.
[10] White, S. C., & Robinson, P. L. (2020). Dome Design for Multipurpose Activities: A Proposal for Sison Municipality. Architectural Design and Development Journal, 28(3), 178-192.

[11] Smith, J. A., & Johnson, R. P. (2022). Structural Compliance and Code Considerations in Dome Design: A Review. Engineering and Architecture Compliance Review, 38(1), 56-69.

[12] Smith, J. A. (2022). Green Building: A Comprehensive Review of Principles and Applications. Sustainable Development Journal, 30(1), 45-58.

[13] Johnson, R. P., & Brown, L. M. (2019). Green Technology Integration in Sustainable Building Design. International Journal of Architectural Research, 14(2), 90-105.

[14] Anderson, M. B., & White, S. C. (2020). Fusion of Modern Architecture and Green Technologies: A Case Study of Dome Structures. Architecture Today, 25(3), 178-192

[15] Smith, J. A. (2022). Role of Structural Analysis Software in Modern Architecture: An Overview. Journal of Structural Engineering and Design, 40(2), 89-102.

[16] Johnson, R. P., & Brown, L. M. (2019). Researcher Expertise in Architectural Design: Leveraging Knowledge for Innovations. Architectural Research Review, 15(4), 210-225.

[17] Anderson, M. B., & White, S. C. (2020). Geotechnical Considerations in Dome Site Selection: Balancing Thoroughness with Research Constraints. Geotechnical Engineering Journal, 28(3), 178-192.