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Integrating Vernacular Masonry Innovations for Climate-Responsive Industrial Architecture: A Case Study of the "Seven Million" Factory

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Abstract: This paper explores the integration of traditional masonry techniques, specifically shallow brick domes and bioclimatic design, within a modern industrial context through a case study of the "Seven Million" factory, Jaugram, West Bengal. By transitioning from energy-intensive reinforced cement concrete (RCC) [3] slabs to "confined masonry" and natural ventilation strategies, the study demonstrates an 8-fold reduction in solar heat intake.
Structural innovation is highlighted through the Muzaffarnagar-Rohtak method, where 6m x 6m shallow domes sustained a 27-tonne load test [3].
Results indicate an Energy Performance Index (EPI) of 142, significantly below the ECBC limit of 180 [1]. Beyond technical metrics, the architectural ethos mirrors the client's own mission: just as "Seven Million" provides a platform for local textile artisans by harnessing natural dyes and techniques, the construction uniquely scales existing vernacular masonry for industrial application.
This unprecedented scaling was driven by a collaborative patronarchitect-artisan framework, proving that pairing traditional wisdom with modern engineering offers a viable, low-carbon alternative for industrial architecture.
Keywords: Vernacular Architecture, Shallow Domes, Bioclimatic Design, Energy Efficiency, Industrial Masonry

I. INTRODUCTION

Traditional industrial architecture often relies on energy-intensive reinforced concrete RCC[3] "black box" designs that necessitate 24/7 mechanical cooling.

This paper presents the "Seven Million" factory—a high-end clothing manufacturing facility near Bardhaman—as a case study for sustainable design.

The core architectural ethos of the project runs parallel to the client's own business model: forging an alliance between local textile artisan communities, natural materials, and global designers. Similarly, the building's construction acts as a mediator to harness and elevate existing vernacular masonry techniques.

While master masons in Western Uttar Pradesh and Haryana have innovated shallow brick domes over the last 40 years, adapting these methods to a massive industrial scale is highly unique. The objective of this paper is to demonstrate how validating these artisan capacities through modern engineering calculations can replace carbon-heavy modern standards to achieve superior thermal comfort and structural integrity.

II. BIOCLIMATIC SITE PLANNING AND PASSIVE DESIGN

The building's architectural framework prioritizes reducing energy demand through passive design strategies before mechanical interventions are considered.

A. Orientation and Geometry

The structure is elongated along an East-West axis. This specific geometric layout minimizes direct solar exposure on the building's primary, broad facades, inherently reducing heat absorption.

Fig. 1 Site plan & orientation

B. *The "Bengal Veranda" Model*

The "Bengal Veranda" Model Emulating traditional Bengal house typologies—where verandas make up 30% to 40% of the house's footprint—a large portion of the building's surface consists of verandas. These well-shaded and abundantly ventilated areas are where traditionally most people spend most of their time, for every possible activity, as opposed to the rooms, kitchen or toilets, which are designed for highly specialised functions like protecting people and belongings from storms and animals, or cooking, etc..

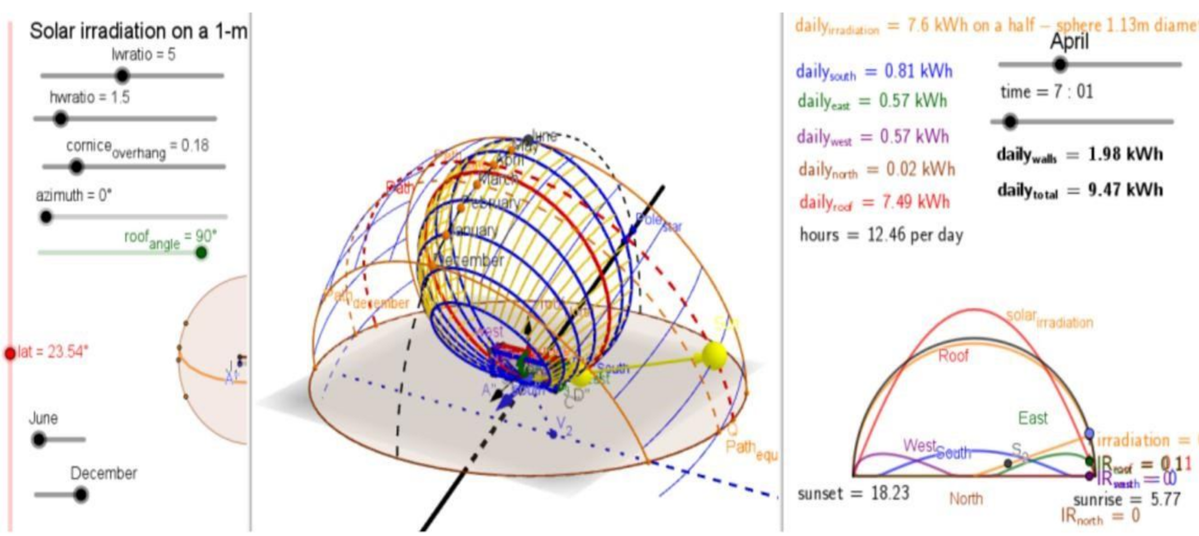

Fig. 2 Solar irradiation chart

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C. Self-Shading Mechanisms and the "Second Skin"

To allow for 100% glazing and maximum natural light without introducing thermal gain, the campus employs tailored self-shading mechanisms across its various structures. For the main multi-story factory building, the design utilizes a highly innovative "second skin" facade. Two-foot-deep planted cornices literally hang from Galvanized Iron (GI) rods at every floor level. This suspended, breathable framework takes the brunt of the weathering and provides complete shade to the North and South elevations. Because of this hanging second skin, the main building can utilize massive glass windows that eliminate the need for daytime artificial lighting while still allowing natural cross-ventilation. Meanwhile, for the auxiliary masonry structures on the campus (such as the dormitories and design studios), deep cornices built with black stones and brick corbels act as "sacrificial elements." These protect the main walls from intense sunlight and monsoon rain far better than conventional plaster and paint, ensuring longevity without relying on steel reinforcement that could rust over time.

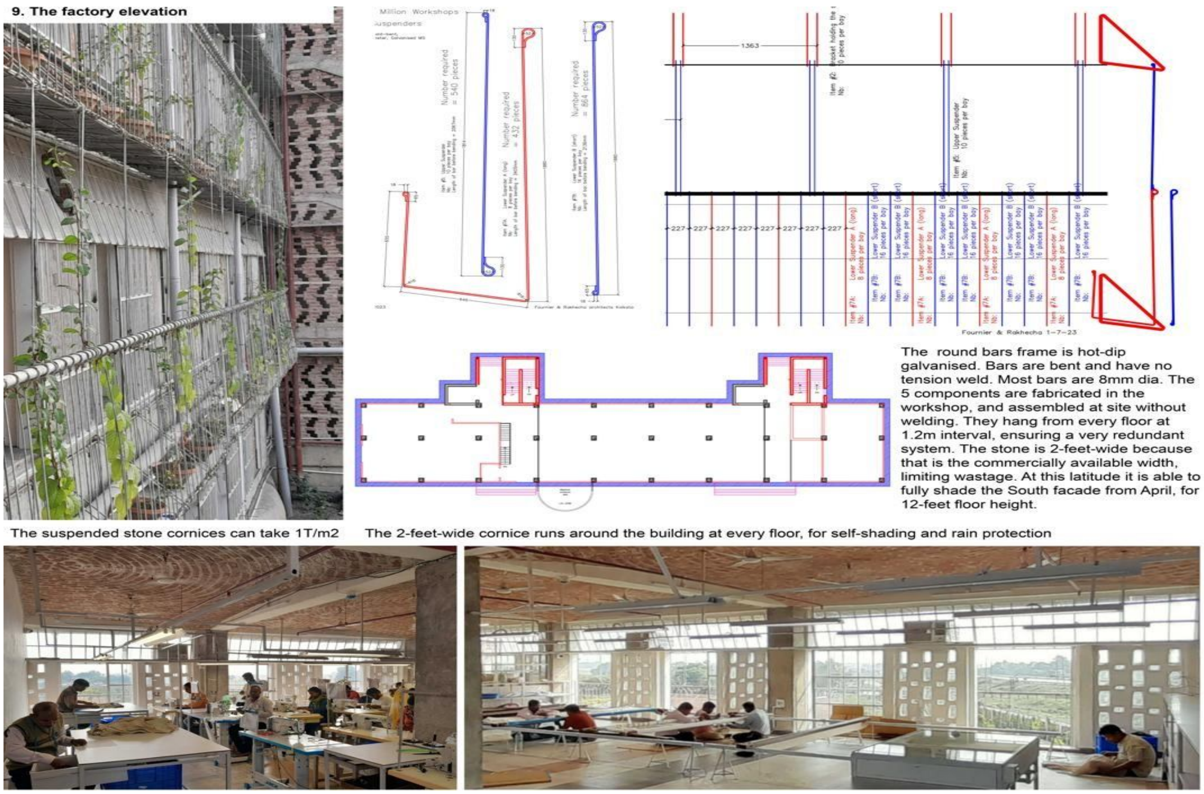

Fig. 3 Façade – Self shading mechanism

III. STRUCTURAL INNOVATIONS: SHALLOW MASONRY DOMES

A core technical innovation of the project is the replacement of conventional flat RCC slabs [3] with high-performance masonry.

1) Scaling the Muzaffarnagar-Rohtak Method: The project employs the Muzaffarnagar-style method to construct 125mm thick shallow masonry domes. This technique embeds steel rebars in bundles, with just enough concrete to ensure longevity, enabling ordinary structures to cover large spans. The uniqueness lies in scaling this rural housing technique to support massive industrial loads safely.
2) Mechanical Advantage: Unlike flat concrete slabs that are prone to tension and shear forces, domes operate under high bi-axial compression. This naturally prevents shear and cracking, ensuring joints remain tightly bound, making the roofing structure inherently more durable.
3) Construction Methodology: These traditional artisan-based techniques enable not only a significant reduction in material cost and construction time, but also, in the vernacular market conditions in which these techniques have been developed and are spreading, a reduction even in the quantity of labour.

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IV. INTEGRATED TECHNICAL SYSTEMS

The factory applies integrated approaches to manage water and waste entirely on-site through zero-energy mechanisms.

A. *Rootzone Treatment*

All kitchen and septic effluent is managed using a hybrid system of absorption trenches and constructed wetlands. By utilizing *Canna Indica* plants, this system treats wastewater organically without requiring costly civil works.

Fig. 4 The sketch diagram of the Rootzone treatment

B. *Spatial Efficiency in ETP Design*

The Effluent Treatment Plant (ETP) was designed as a two-storied masonry structure built with domes. This innovative vertical integration effectively reduced the required land area footprint by 50%.

Fig. 5 Water tank & ETP construction

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V. TECHNICAL VALIDATION AND RESULTS

The performance of these masonry and bioclimatic innovations was validated through rigorous empirical testing and simulation.

A. *Thermal Performance and Energy Index*

Using GeoGebra geometry software, it was calculated that a standard unshaded square building absorbs 2803 kW-h of solar heat per day in April. In contrast, the elongated, shaded, and insulated design of the "Seven Million" factory absorbs only 385 kW-h per day—an 8-fold reduction. During peak summer, meetings were conducted comfortably utilizing only natural cross-ventilation. This theoretical passive cooling was empirically validated through the site's actual electricity meter readings over a 12-month period. The total annual electricity consumption for the 4,140 m² built-up area was 589,583 kW-h[2]. This results in an **Energy Performance Index (EPI) of 142**. Not only is this well below the Energy Conservation Building Code (ECBC) maximum limit of 180[1], but it successfully places the factory in the top tier of energy-efficient buildings in India, which typically range between an EPI of 100 to 150[1]. Furthermore, electricity consumption showed a strong correlation with factory production rather than weather, proving the success of the passive thermal shielding.

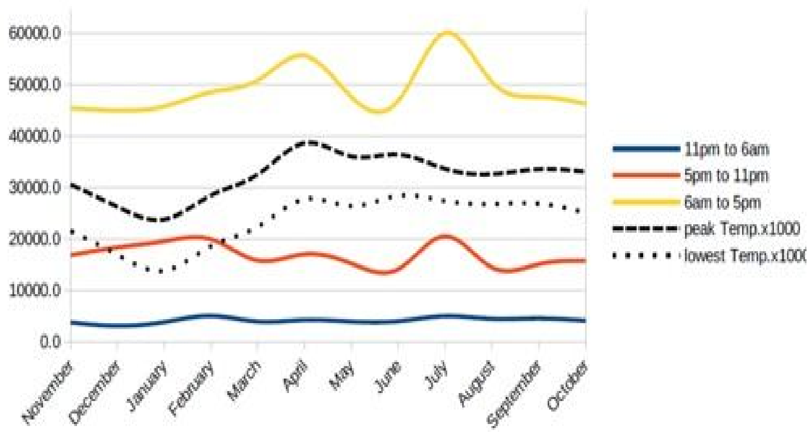

Fig. 6 Electricity Meter Monthly Readings in kW-h for the entire Site 1 (stacked values, smooth lines), November 2023 to October 2024, and air temperature at Kolkata Airport

B. *Structural Load Testing*

To validate structural safety, a 6m x 6m shallow dome—designed for a live load of 500 kg/m²— underwent a load test. The dome was loaded with 27 tonnes (150% of its design capacity) [3]. It recorded a maximum deflection of just 2.48mm[3] and, upon unloading, demonstrated a remarkable recovery rate of 95% to 100%[3] .

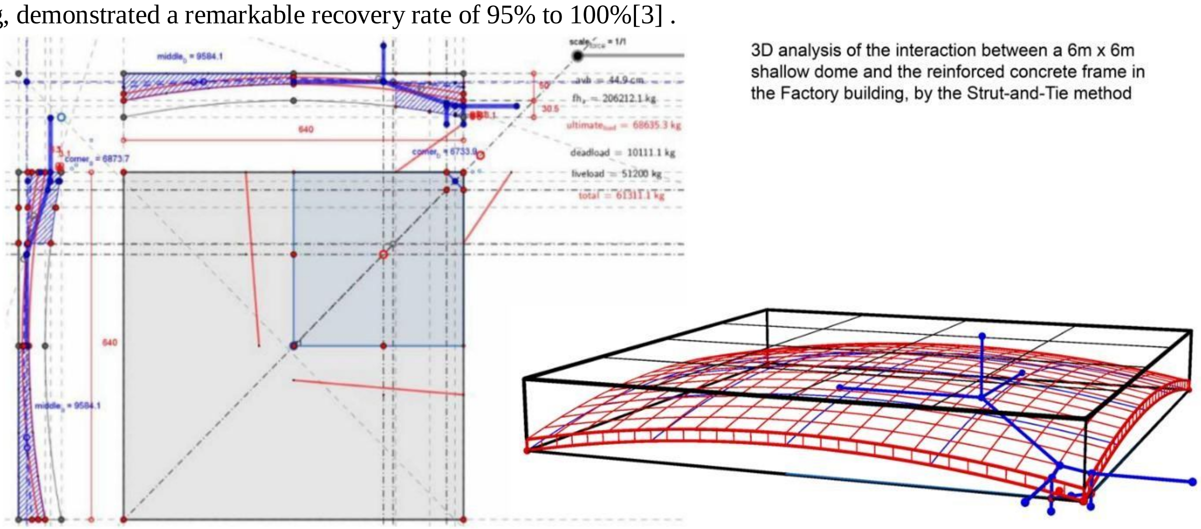

Fig. 7 3D structural analysis

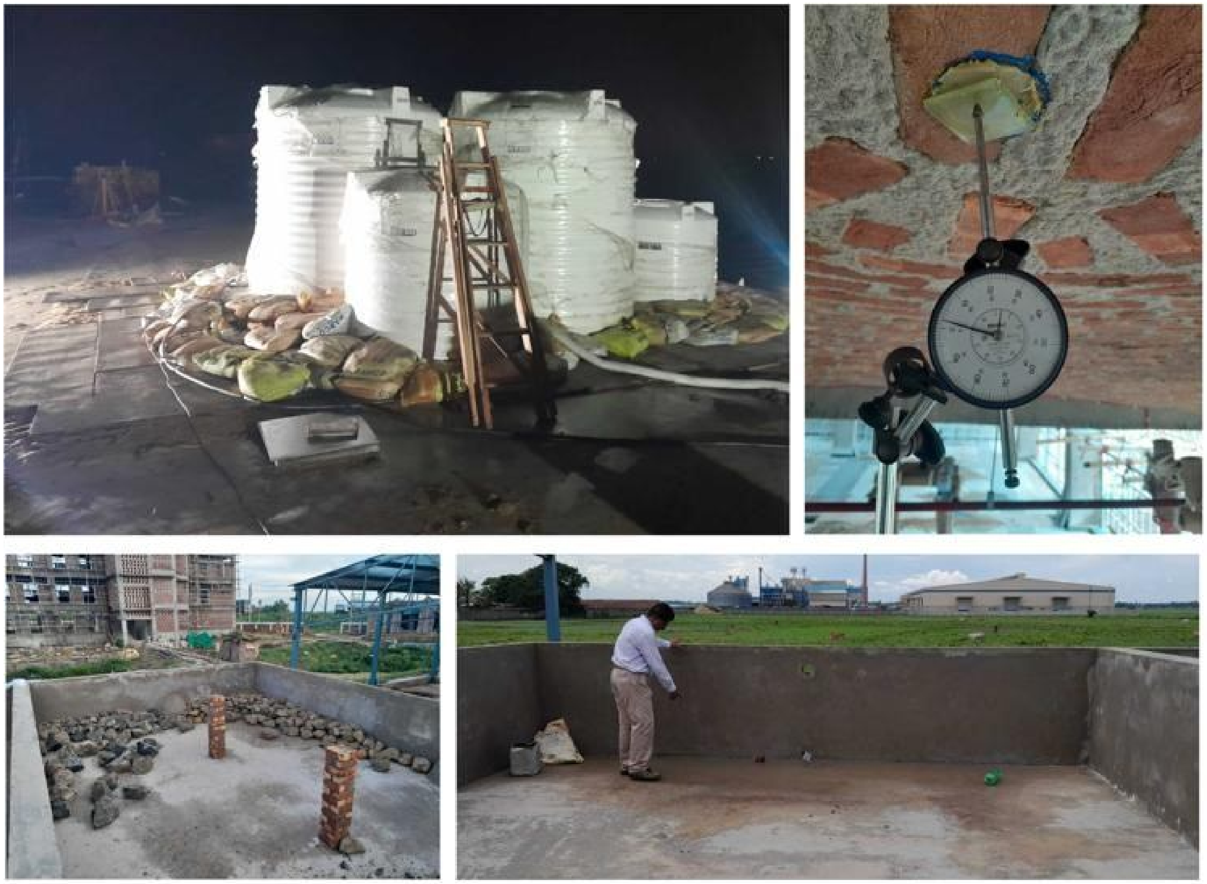

Fig. 8 Load test results

VI. FUTURE PROJECTS

The success of scaling these masonry techniques to an industrial level highlights that true sustainability is inherently collaborative. It requires bridging the gap between traditional craftsmanship and modern industrial demands. This approach provides a highly scalable model for the future of rural industrialization and low-cost sustainable housing.

VII. CONCLUSIONS

The integration of traditional artisan skills with modern engineering calculations validates the environmental and structural superiority of vernacular architecture. The "Seven Million" project physically embodies the ethos of "restoring the people's trust in their own capacities," proving that local, natural methods—whether in weaving textiles or constructing roof slabs—can successfully thrive at a commercial scale.

VIII. ACKNOWLEDGMENT

The authors would like to express their gratitude to Bapan and Lucie Dutta for having extended their philosophy of crafts revival beyond their core activity of textiles, into the construction of their buildings, resulting in many local masons from West Bengal being trained for several months by the very best domes masons in India, and for some of them, being able to continue on their own. (Tapas Ghosh and Abu from Bardhaman, Prabir Hazra from Murshidabad).

Acknowledgment is also extended to Om Dayal Group of Institutions for facilitating the IASI 2026 conference.

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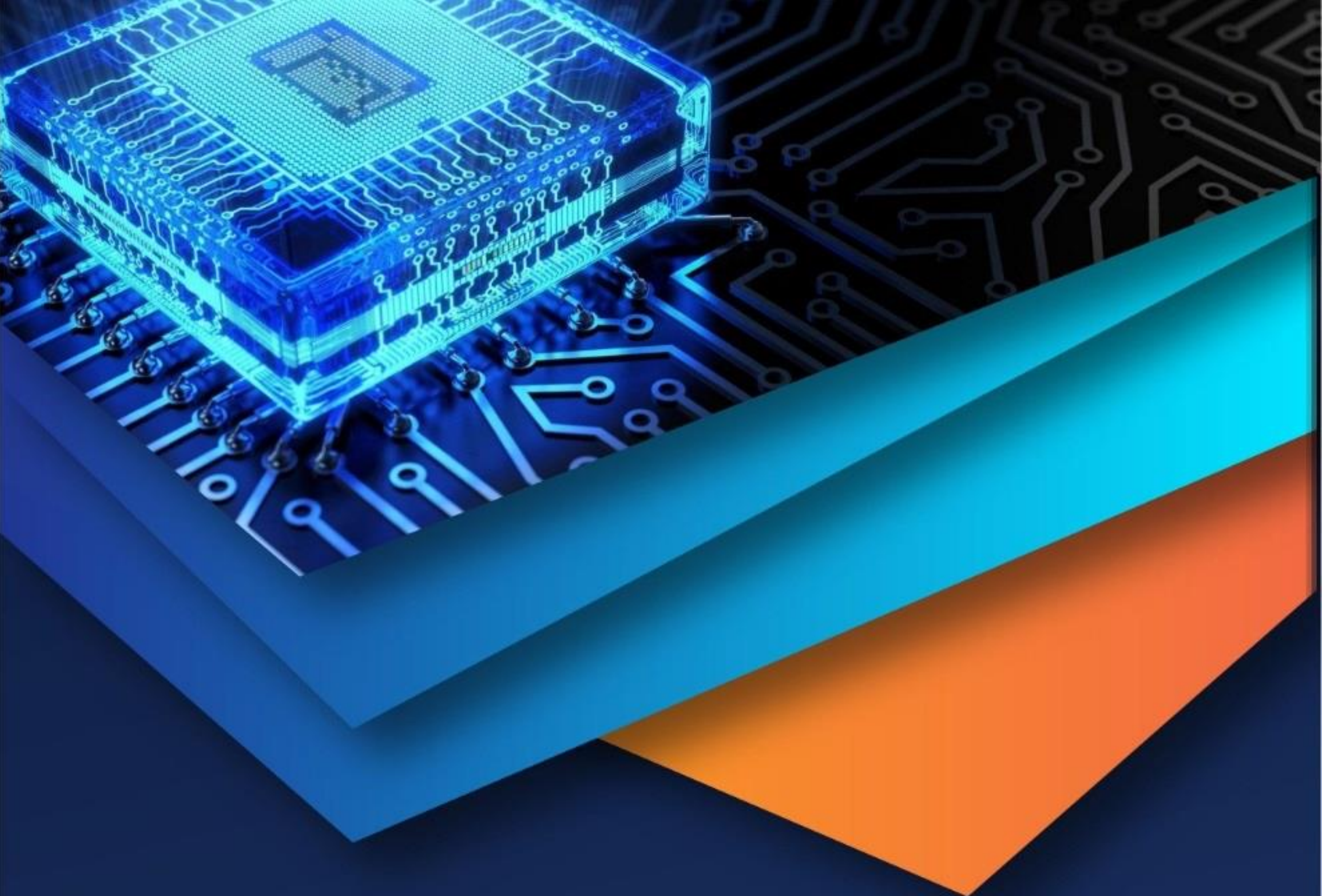

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