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Review on Timber Portal Frames and Their Architectural Characteristics

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Abstract: Portal frames being the effective methods of construction today, have a lot to study in terms of their efficiency and material behavior. This review paper focuses on Timber as the material for the frames and its relevance. It involves the architectural features and its use in different types of occupancies with its changing character.
Keywords: Timber, cost effective, reliable, simple construction.

I. INTRODUCTION

Portal frames have been in use since the 1960s and are primarily employed in larger, more industrial construction projects with spans of larger than 15–20 meters. A portal frame lacks the inner and web elements of a truss, relying instead on the columns' stiff attachment to the rafters. Aside from the benefit of increased space due to the elimination of web members, portal frames are often less labour intensive and less expensive to construct, and have only been employed in bigger industrial style construction till now.
Similar to concrete building structures and hot-rolled steel buildings, material features and attributes have a considerable impact on the behaviour and performance of timber portal frames. Fast, cost-effective building of smaller structures such as garages and carports as well as industrial storage racks is in high demand. As a result, a comparison is made between presently accessible ways of designing and constructing both classic timber truss-based systems and residential-sized timber portal frames. Timber portal frames for small-scale residential projects do not appear to be a popular choice.

A. Definition

Portal frames can be defined as two-dimensional rigid frames that have the basic characteristics of a rigid joint between column and beams. They are one of the most popular structural applications for commercial and industrial buildings because of the superior strength and structural efficiency. The main objective of this form of design is to reduce bending moment, which allows the frame to act as one structural unit. Driven by the need to achieve low-cost building envelope. They are usually made from steel but can also be made from concrete or timber.

B. History

First Portal frames were developed during World War II, and became popular in the 1960s. Today, they are used to create different kinds of enclosures, particularly warehouses, agricultural buildings, hangars, factories, as well as retail and storage facilities.
First Portal Frame was at the Exposition Universally in Paris 1878, the engineer Henri De Dion progressed the science of vaulting of lattice girders where the forces were transmitted directly to the foundations without tie bars. It spanned for 35m and its pitched roof shape was a forerunner to follow ahead. Such a masterpiece created at that time had made a benchmark for the upcoming innovations and techniques to be used for their construction. This resulted in the better outcome till today's date where the structures span more and serve the best for the durability and strength.

II. LITERATURE REVIEW

Review on Development of Wooden Portal Frame Structures. Authors: Masahiro Noguchi, Kohei Komatsu Most housing in Japan has a 20–30 year lifespan. Poor durability as a result of the house's old-fashioned use is a determining factor of concern. As a solution to this issue, houses can be built with a skeletal framework that allows future owners to freely split spaces. Multistory frames with spans of 6 to 10 m are necessary to create the skeleton structure adequately. There are two different kinds of wooden portal frame structures that were proposed. Both constructions contain glued-in short horizontal members that improve the vertical columns.
The goal of this study was to investigate for good structural solutions for these columns. The moment-transmitting ductile connection with the improved columns was relocated in the first kind of the new structure. An enlarged panel zone was employed in the second type of structure. They tested nine portal frame specimens.

When compared to the control, the stiffness and strength values were improved by roughly 1.7 and 3.5 times, respectively. Therefore, the portal frame structures with improved columns have structural advantages, especially stiffness. (Noguchi et al., 2006).

A. Review on Timber Portal Frames vs Timber Truss-Based Systems for Residential Buildings

Authors : Harry Far, Claire Far

The intention of this examine is to have a take a observe the feasibility and financial incentive that can be won from the use of a wood portal body system, much like the metallic or wood portal frames used for large business constructions, over the conventional wood truss and column arrangement. The use of wood portal frames over wood truss structures proved to have benefit with regards to usual value and guy strength involved. The concept of the use of timber portal frames for small-scale residential systems does not seem to be popular. With a excellent deal of large-scale metallic and timber portals round for decades, the concept of this examine was to decide if there may be a possible motive that those portal constructions have now no longer made their manner into the residential construction market. (Far & Far, 2019)

B. Review on Resilient Technologies for Sustainable Infrastructures

Authors: Anthony Abu

It talks about the risk analysis in the design of timber portal frame with semi-rigid knee joint by using wood as material leading to strength and failure criteria. It also talks about the assessment of the consequences of deformations developed due to load and its impact in semi-rigid connections which is an important element in a sustainable design.

The resistance of wood in tension perpendicular to the direction of the grain, development of deformation and uncertainty of bearing capacity are important factors which are looked taking into the safety aspects. (Ozola & Fabriciuss, 2021)

III. METHODOLOGY

The methodology involves the procedure followed for the timber portal frames to be constructed and erected.

Timber Portal Construction has following main aspects

1. Design

Architect showcases plans for the design

Engineer works on its engineering drawings

2. Manufacture

Subcontractor does his job in contact with the supplier and hence timber mills

Offsite manufacturing by the subcontractor

Client gets the result from all these contributions.

Builders on site construction related to the type of

3. Construction

Crane operators

Laborers

Builders built according to the Architect and

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The following are the steps in the construction of portal frames:

1) The column holes and connections are dug and concreted in.
2) The rafters and columns, which are the portals, are built on the ground and joined by plywood gussets.
3) The portals are tilted up and joined by purlins and girts after construction.
4) All mullions, lateral load resisting, and other structural elements are connected.
5) Finishing elements like cladding and roofing are installed.

A. Designing Timber Portal Frame

1) Timber portals can span up to and above 50 meters, depending on the knee joint and member size.
2) Timber may be shaped into any shape, giving the architect a lot of options.
3) Steel hinges can be utilized for efficient erection and enhanced strength on big span timber entrances.
4) Steel gussets can also be utilized to increase the strength of knee joints.
5) Nailing is a significant and well-defined aspect of structure design.
6) Poor nailing can lead to structural failure.
7) Timber portal frames can also carry considerable weights on the members, allowing for additional attachments like as cranes and machines to be incorporated in.

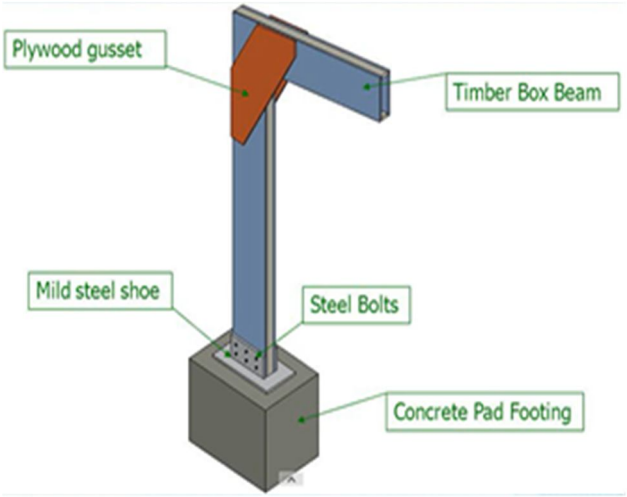

Figure 1: Timber Portal Model , source: slideplayer.com

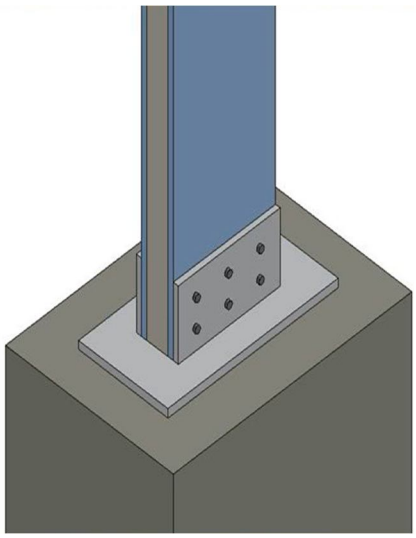
Figure 2: Timber Portal Model , source: slideplayer.com

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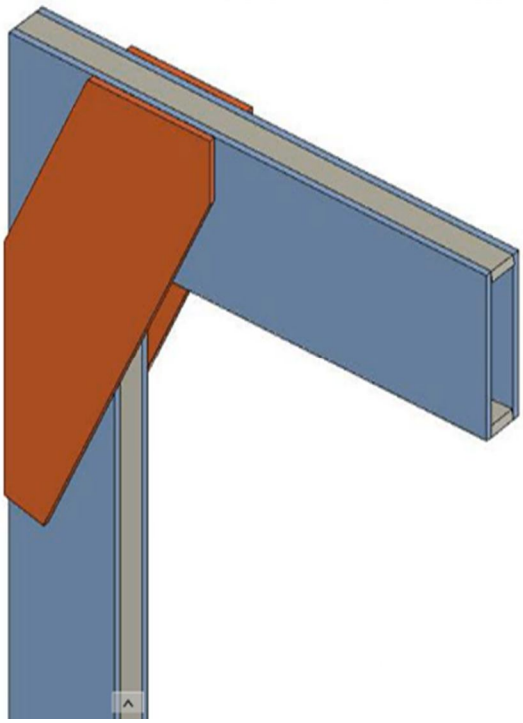

Figure 3: Timber Portal Model , source: slideplayer.com

B. Manufactured Timber Portal Members

1) On a linear axis, LVL (Laminated Veneer Lumber) has a high strength and may be created in great depths and lengths.
2) Glulam (Glued Laminated Timber) — a versatile member made of small pieces of wood glued together that may be constructed in large depths, widths, lengths, and shapes, including curves.
3) Plywood is frequently used in conjunction with other woods to generate a component that can withstand shear loads. For example, shear forces will be transferred via the web of a built-up box beam section. It can be used as decorative paneling or to support out-of-plane loads on flooring.
4) Engineered Strand Lumber (ESL) is a multipurpose product comprised of clumps of wood fiber arranged in a mostly linear pattern and glued together.
5) OSB (Oriented Strand Board) is a panel product made from thin wood wafers glued together. During manufacturing, the wafers are positioned so that the grain runs mostly parallel to the board's length.
6) Box Beams are similar to small stud walls that are covered with plywood. You create the stud to the size beam needed, then box it in with plywood. The longer the span, the deeper the beam and the more studs.

Large lengths of timber were once utilized to span vast distances.
This type of wood is now too difficult and expensive to obtain.
To make a single timber structural member, various structural elements are combined to form a timber portal member.
These are made to give a single timber part that can cover longer distances than a solid wood shape can.
Depending on the length of the span, they can be made from a variety of wood stress classes.
High stress grade timbers, such as F17, would be utilized for broad spanning timber entrances.
Large spanning beams can be cut into portions for easier transport, and sections can be lifted into place rather than using cranes.

C. Prefabrication

Depending on the type of wood, timber members can be built on-site or pre-fabricated off-site.
Prefabrication will allow the slab to be poured while the frame is being constructed off-site, saving time.
On-site construction means that the frame may be erected on the ground and then lifted into place using cranes, saving money and alleviating safety concerns.

D. Load Transfer

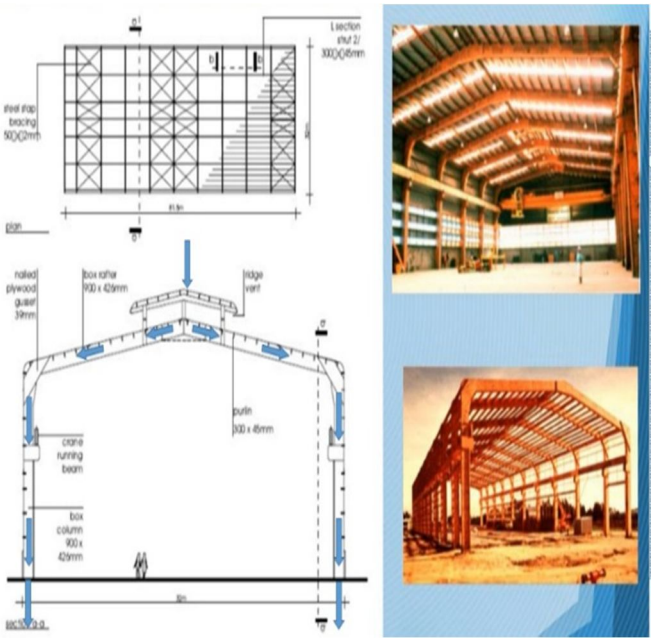

Figure 4: Basic timber portal frame plan and section, source: slideplayer.com

IV. CASE STUDY

MIM Itinerant Museum of Memory and Identity of Montes de María

Figure 5: Museum, source: www.archdaily.com

A. Aim of the Study

To study and understand the use of timber and its relevance in Portal frame construction.

B. Project Details

Architects: Carlos Puerta, Verónica Ortiz (AEU)
Area: 179.15 sq. m.
Location: Colombia
Typology: Museum, Temporary installations
Structural system: Portal-frames
Material: Timber

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C. Background

The museum was designed to represent a platform for symbolic healing of wounds left by armed conflict, seeking to strengthen coexistence, organization, and social mobilization, through dialogue and confluence in its roaming around the territory.

The building tries to conceive as an itinerant device to recover communities' speech with the objective of making memory a path for a reunion, overcoming fear and pain.

D. Concept

To create a flexible structure which can be erected and collapsed whenever and wherever required within economic cost. The modular system allows building assembly and disassembly to be carried out in 3 days, obtaining storage and transport agility, and easing its packaging, a fundamental aspect that responds efficiently to 3 months estimated museum roaming time.

The Museum required column free circulation spaces to make people experience through unobstructed displays and visuals.

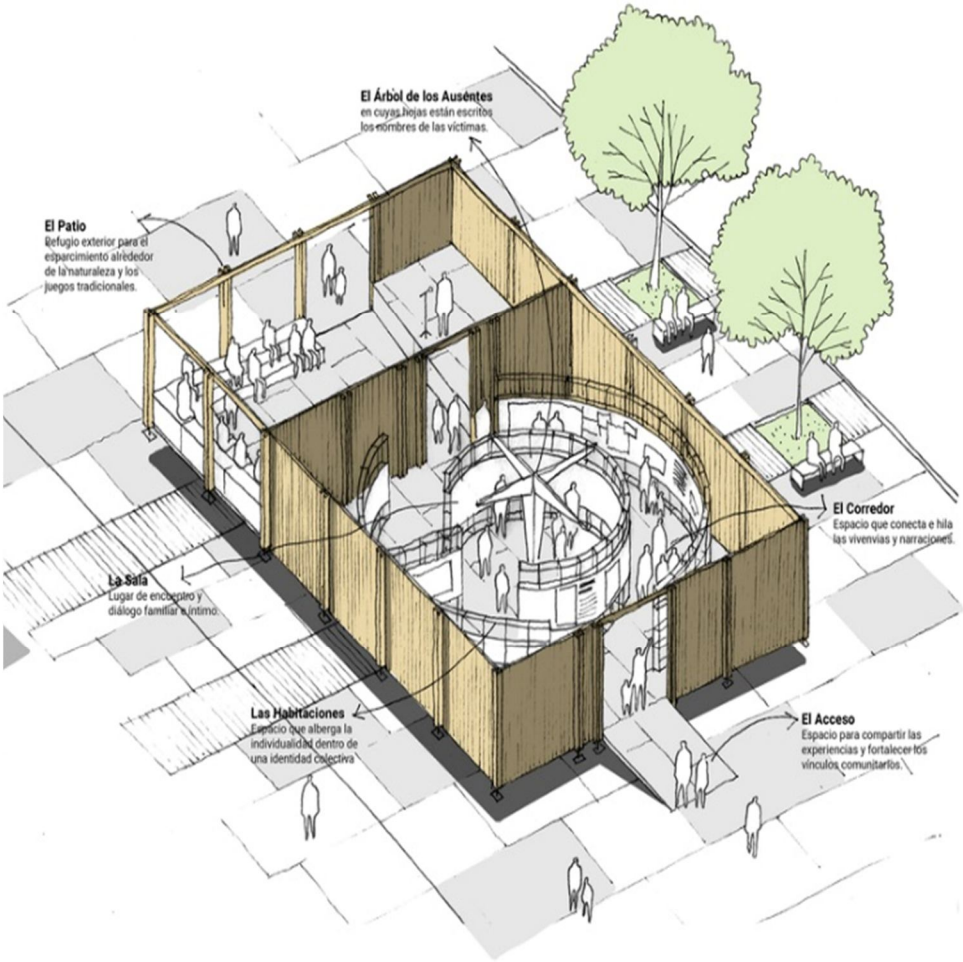
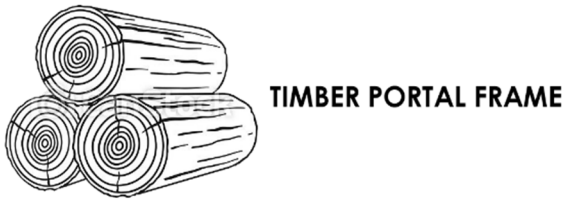


Figure 6: concept, source: www.archdaily.com

E. Material

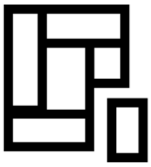


Timber Portal Frames solve five important premises:

1 2 3


Economic Cost


Adaptability


Modularity

4 5


Climatic Comfort


Earthquake Resistance

Thus, 179.15 m^2 museum is a collapsible pavilion built in a perimeter-portal-frames structural system with glued laminated timber and metal joints and anchors.

F. Technical Details

Its structure is made up of adaptable to terrain irregularities metal legs, modular 2,54 m wide and 2,75 m long wooden beams and columns grid, vertical wooden blinds enclosure that facilitates interior museum space natural ventilation and lighting, and opal cellular polycarbonate cover cladding.

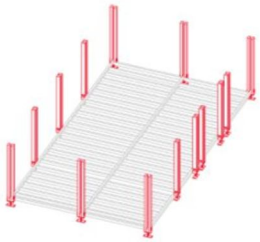
Figure 7: Framings, source: www.archdaily.com

G. Spatial Quality

The relationship of the exterior to the interior is unhurried, which provides a welcoming transition toward the moving content, exhibited in spatiality and walkthrough that invites reflection.

Following diagrams show the erection stages of Portal frame along with Timber trusses.

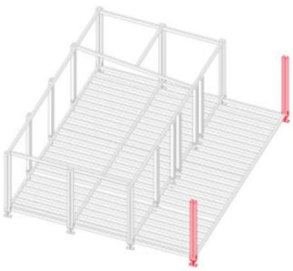
Stage 1



Stage 2

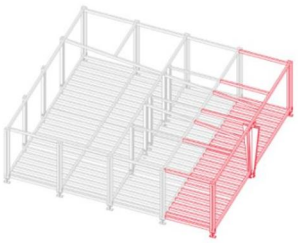
Stage 3

Stage 4

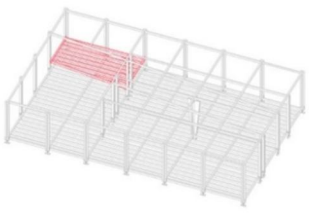


Stage 5

Stage 6



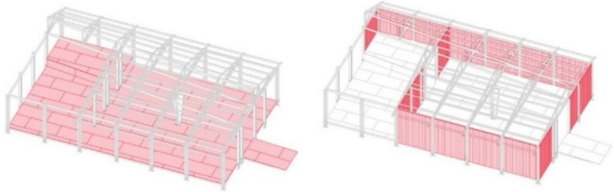
Stage 7



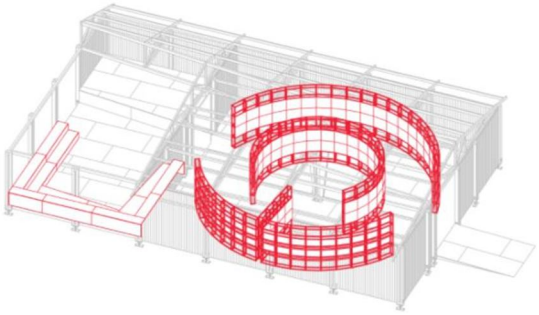
Stage 8

Stage 9 *Stage 10*

Stage 11 *Stage 12*



Stage 13 *Stage 14*



Stage 15

Figure 8: Stages of Construction, source:www.archdaily.com

V. CONCLUSION

Wooden portals are one of the most aesthetically attractive alternatives for structures that require large spans and column free spaces interiors without columns. According to the research, using Portals rather than Trussing Systems would be a superior alternative for saving time and money. The construction of the gantry uses modern engineering technology to make wood a highly effective, efficient and economical construction product.

This illustrates how a portal may be constructed based on the intended use, since most porches are thought to be utilized mostly in warehouses, but they can also be used for other pillarless areas such as exhibits, school for children, and so on. Most people customize them now that they are popular because to the gap-free areas.

Also highlighted in the research of timber materials used in portals, their architectural features as seen in the case study of MIM itinerant museum of memory how they have created exhibition space obey portal frames then light and ventilation, and the use of ecological materials to demonstrate the relationship between building and nature.

Simple construction, less time required, earthquake safety, economic costs, recycling, climatic comfort, adaptability makes timer more preferable. Simple construction, reduced time necessary, seismic safety, cost effectiveness, recycling, climatic comfort, and flexibility make timers more appealing.

Aesthetics can be achieved through large column free spaces which can be achieved by the portal frames with suitable shapes and spans. Timber being a super material proves to be a architectural masterpiece where the structures are adaptable to the climatic and seismic conditions as they may prevail**.**

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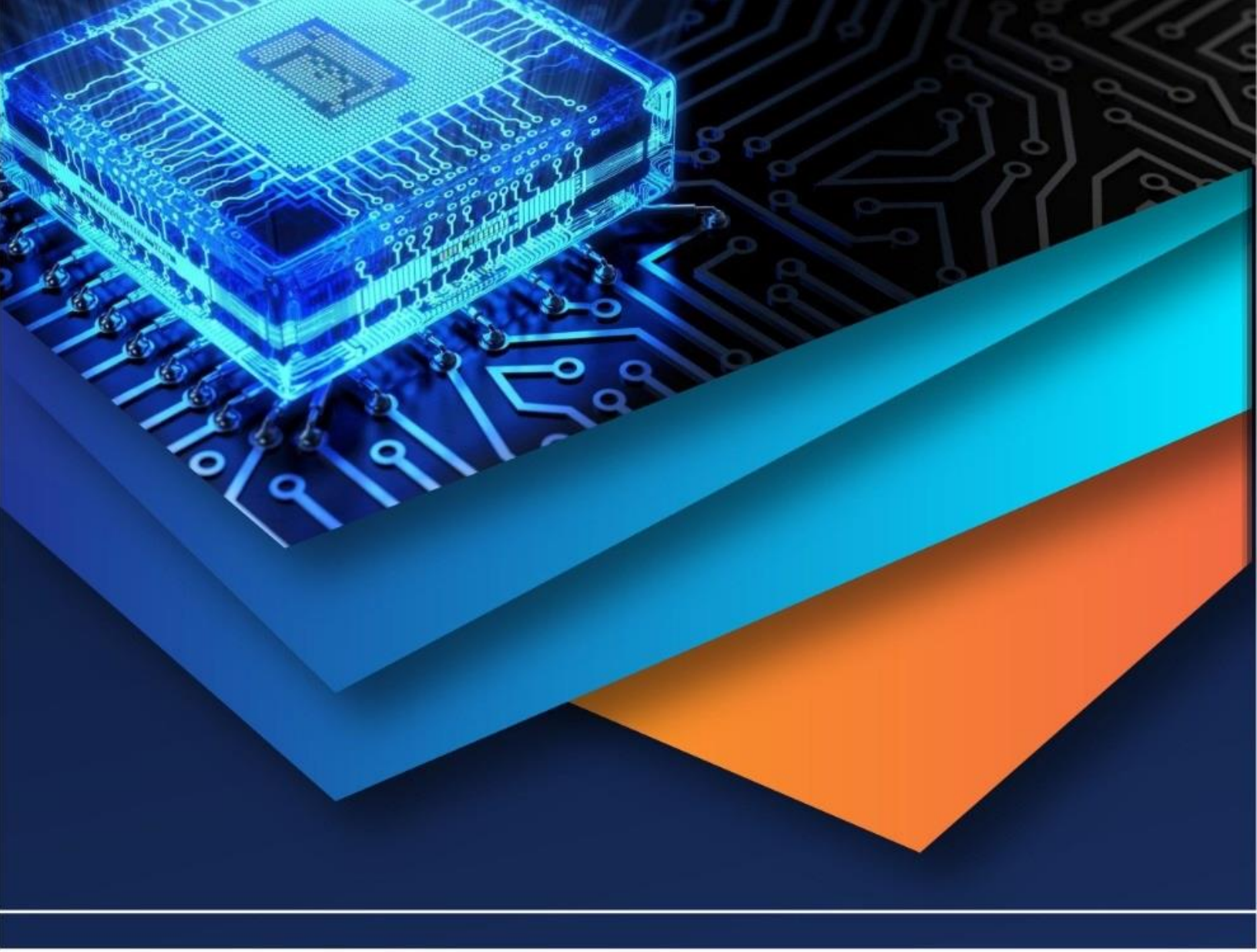

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