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Structural Materials of Building: A Closer Look

Rutvij Patel[1]
Pooja construction

Abstract: ***The process of creating a structure involves many steps, and the building materials are a crucial one. When building a structure, it is important to understand the properties of both man-made and natural elements. When it comes to the specifics of the materials used in the building business, caution must be taken. It is imperative to acknowledge the existence of a physical material mechanism. The material's costs for the economy, environment, energy, and society have all been examined in this document. This document discusses materials that are natural, artificial, or living. This document also covers the materials that impact the building's strength and quality.***
Keywords*: Building Material, Natural Materials, Man – Made Materials, Living Building Material, Costs*

I. INTRODUCTION

Building materials are those that are utilized in construction. Many materials found in nature, including wood, sand, pebbles, clay, and even twigs and leaves, have been utilized to build structures. In addition to materials found in nature, man-made products are widely used, varying in their degree of synthetic nature. Many nations have well-established industries dedicated to the production of construction materials, and the usage of these products is usually limited to specialized crafts like carpentry, insulation, plumbing, and roofing. They supply the building blocks for homes and other constructions.

Building materials have changed throughout time from being mostly natural to being more man-made and composite, biodegradable to imperishable, indigenous (local) to being moved around the world, repairable to throwaway, and selected for better seismic and fire resistance. The short- and long-term financial, environmental, energy, and social costs of construction materials are generally rising due to these factors.

A. Economic Cost

The purchasing price of building materials represents their original economic cost. This frequently serves as the basis for choosing which materials to utilize. Sometimes individuals see the advantage in paying a greater initial cost in exchange for a reduced lifetime cost because of the material longevity or capacity to save energy. For instance, installing an asphalt shingle roof is less expensive than installing a metal roof, but because of the metal roof's longer lifespan, the annual lifetime cost will be lower. The ultimate choice may also be influenced by sustaining expenses particular to materials, since certain materials could need more attention than others. When calculating a material's lifetime cost, there are two potential risks: either the material is not as durable as promised, or the building sustains damage from wind or fire. To mitigate the risk of purchasing combustible materials to extend the lifespan, the cost of materials should be considered. "If it has to be done, it has to be done well," as the saying goes.

B. Ecological Cost

Costs of pollution can be both large and micro. The extraction industries that provide building materials, like mine, petroleum, and logging, cause environmental contamination at the source and during the raw material transportation, product production, product transportation, retailing, and installation. The off-gassing of construction materials within a structure or interior air pollution are examples of micro aspects of pollution. Materials on the Red List are ones that have been determined to be dangerous. Additionally, there is the carbon footprint, or the total amount of greenhouse gas emissions generated during the material's life. Construction waste reuse, recycling, and disposal are all included in life-cycle analyses. Green construction and sustainable development are two architectural concepts that take the ecological economics of building materials into account.

C. Energy Costs

The energy used to create, transport, and install the material is included in the initial energy expenses. The financial, environmental, and social expenses associated with continuing to produce and supply energy to the building for its use, upkeep, and ultimate removal are known as the long-term energy cost. The energy required to extract, manufacture, deliver, and install the materials makes up the original embodied energy of a structure.

The usage, upkeep, reuse, recycling, and disposal of the building materials themselves, as well as how the materials and design work together to reduce the structure's overall energy consumption, all contribute to the lifetime embodied energy.

D. Social Cost

Social expenses include harm to the worker's bodies during the production and transportation of the materials as well as possible health issues for building inhabitants if building biology issues arise. People have been greatly impacted by globalization in terms of employment, skills, and self-sufficiency due to the closure of industrial facilities and the cultural differences in the areas where new operations are created. Global building material manufacture has societal costs related to worker rights and fair trade.

II. BUILDING MATERIALS

A. Natural Materials

1) Brush

Primitive tribes like Native Americans and the Pygmies of Africa utilized brush buildings, which are made entirely of plant components in Fig 1. These are constructed primarily from bark, twigs, and branches, much like a beaver's lodge. They went by several names, like wikiups, lean-tos, and so on.

The wattle and daub method, which fills in and covers a woven brush structure with clay soils or cow dung, is a continuation of the brush building concept. As a result, the structure gains strength and thermal mass. Building using wattle and daub is one of the oldest methods. Wattle and daub are a common non-load-bearing wall material used in older timber frame constructions.

Fig 1. A Group of Mohaves in Brush Hut

2) Ice and Snow

The Inuit people utilized snow and sometimes ice to construct igloos, and they also used snow to construct quinzhees, which are covered shelters. In colder climates, ice has also been utilized to create ice hotels, which are popular tourist attractions.

3) Mud and Clay

Buildings made of clay often fall into one of two categories. There are two methods for creating walls: one involves using the mud mixture directly, and the other involves stacking mud bricks, which are air-dried building blocks.

Clay is also used in construction to make mud plaster, light clay, and wattle and daub. It is also blended with straws.

4) Wet Laid Clay Walls

The mud or clay mixture is used directly, without shaping blocks and drying them first, to create wet-laid, or damp, walls. Different architectural styles are produced depending on the kind and quantity of each element utilized in the mixture. The quality of the soil being used is typically the determining factor. More clay is typically used when building with cob, whereas sod houses or roofs are typically constructed with low-clay soil. Straw or grasses and sand or gravel make up many of the other elements. Both an older and a more modern method of building walls are known as "rammed earth." Originally, forms and mechanical pneumatic compressors were used to manually crush clay soil between planks.

Soil, particularly clay, has a high thermal mass and is excellent at maintaining a steady temperature. Homes constructed of earth typically have a natural tendency to be warm in the winter and cool in the summer. Like stone, clay retains heat or cold and releases it gradually. Because earthen walls absorb heat and release it more slowly than, say, a house built of wood, artificially raising or lowering the temperature can require more energy but the effect lasts longer.

Homes made of primarily earth and clay, such as cob, sod, and adobe, have been erected for ages throughout western and northern Europe, Asia, and the rest of the world. Construction is still going on, albeit on a smaller scale. There are some of these structures that have been inhabited for hundreds of years.

5) Structural Clay Blocks and Bricks

Evidence of mud-bricks, or adobe in Spanish, dates back thousands of years BC, making them an old building material. at modern industrialized societies, compressed earth blocks are a more common type of brick used for construction since they can be produced off-site at a central place at a brickwork and then transported to various building locations. Additionally, it is easier to monetize and sell these blocks.

Clay is nearly always used to make structural mud bricks; typically, only clay soil and a binder are needed, while other materials may include sand, lime, concrete, stone, and other binders. After the crushed or formed block has air dried, it can be put flat or covered with clay slip or mortar.

6) Sand

For plastering and masonry projects, sand, cement, and occasionally lime are combined to create mortar. Additionally, sand is added to the concrete mixture. Sand Crete blocks are a popular low-cost building material in nations with soils that include a lot of sand; they are less durable than baked clay bricks but still cost less.

7) Stone or Rock

There have been rock formations for as long as recorded history. It is typically easily accessible and the most durable building material available. There are numerous varieties of rock, and each has unique qualities that make it ideal or undesirable for a certain application. Since rock is so solid, it provides a great deal of protection; nevertheless, its weight and labour-intensive nature make it an unsuitable building material. Its energy density has benefits and drawbacks. Stone is difficult to heat without using a lot of energy, but once it is heated, its thermal mass allows it to hold heat for extended periods of time.

For as long as people have piled stones on top of one another, dry-stone walls and houses have been constructed. Over time, various types of mortar were employed to secure the stones, with cement currently being the most widely utilized type.

For example, the United Kingdom's Dartmoor National Park's granite-strewn uplands offered plenty of resources to early settlers. Throughout the Neolithic and early Bronze Ages, round cottages were built out of loose granite boulders; an estimated 5,000 of these structures' remnants can still be seen today. Granite was still in use throughout the Middle Ages and into the Modern Era (see the Dartmoor longhouse). Another type of stone that is frequently used for roofing is slate, which is found in the UK and other regions of the world. Most large towns have stone structures, and certain civilizations, like the Inca culture and the pyramids of Egypt and the Aztecs, built most of their structures out of stone.

8) Thatch

One of the earliest known construction materials is thatch. "Grass" is another word for "thatch"; it is easily gathered and acts as an excellent insulator. For a long time, many African tribes have fashioned their homes entirely of grass and sand in Fig 2. Thatch roofs were originally common in Europe, but as transportation and industry improved and other materials became more accessible, thatch roofing became less and less popular. However, a resurgence of the practice is currently taking place. For example, a lot of newly constructed homes in the Netherlands feature thatched roofs with unique ridge tiles on top.

Fig 2. Toda Tribe Hut

9) Wooden and Timber

In its natural state, wood has been utilized for construction purposes for thousands of years in Fig 3. In modern industrialized nations, manufactured wood is becoming increasingly prevalent.

When cut or pressed into lumber and timber, such as boards, planks, and similar materials, wood—a byproduct of trees and occasionally other fibrous plants—is utilized in construction. It is a universal building material that may be utilized in most climates to build almost any kind of structure. When loaded, wood can be exceedingly flexible, maintaining strength while bending, and it can withstand tremendous vertical compression strength. Even within the same tree species, there are numerous differences in characteristics between the various varieties of wood. This indicates that certain species are more appropriate for a given purpose than others. Furthermore, quality is determined in part by growing conditions.

Except in the United States, where the term "lumber" is used, "timber" is the term used in building. When raw wood (a log, trunk, or bole) is "converted"—sawn, hewn, or split—it becomes timber. Examples of this include light-frame building, timber frame construction, and minimally-processed logs stacked on top of one another. The two biggest issues with timber structures are moisture-related issues and the possibility of fire.

These days, hardwood is typically utilized for furniture and finishings, while softwood is used as a bulk material with lower value. In Western Europe, oak was traditionally used to build timber frame structures; but, in recent times, Douglas fir has emerged as the most widely used wood for most structural building types. In rural locations, a lot of households and towns have their own woodlot where they plant and harvest trees for their own use or to sell. These lots receive the same care as a garden. This is still a viable method of agriculture, but it was far more common in pre-industrial periods when there were regulations governing the amount of wood that could be cut at any given time to guarantee a supply of timber for the future.

Fig 3. A Wood – Framed House Under Construction in Texas, United States

B. Man – Made Material

1) Fired Bricks and Clay Blocks

Bricks are made similarly to mud-bricks, but without the fibre binder like straw. To make them permanently hard, they are burnt, or "burned," in a brick clamp or kiln after they have air-dried in Fig 4a. Bricks made from kiln-fired clay are made of ceramics. Fired bricks can have hollow interiors or be solid to help with drying and to make them lighter and more portable. Using mortar, the individual bricks are stacked one on top of the other in courses. The construction of walls, arches, and other architectural features is done in successive courses. Compared to cob/adobe, fired brick walls are typically much thinner while maintaining the same vertical strength. Although they are lighter than stone blocks and require more energy to produce, they are also easier to transport and store. Roman bricks are named for the shape and type of burnt brick that the Romans employed frequently. In Brick construction became very popular in the middle of the eighteenth and nineteenth centuries. This resulted from rising brick production and fire safety in the ever-crowding cities at cheaper rates.

In the latter half of the 20th century, cinder blocks either supplemented or replaced burnt bricks, and they were frequently employed both alone and for the inside of masonry walls.

Clay or terracotta structural clay tiles, also known as clay blocks in Fig 4b, are usually hole-perforated.

Fig 4a. Fired Bricks

Fig 4b. Clay Blocks

2) Cement Composites

Pre-cast building components are created by binding wood, particles, or fibres together with hydrated cement paste. This process is known as cement bonded composites. As binders, a variety of fibrous materials have been employed, such as paper, carbon fibre, and fiberglass.

Various soluble organic components, including sugars, glycosides, and phenolics, make up wood and natural fibres. It is well known that these substances slow cement setting. As a result, a wood's suitability for use in cement-bonded composites is determined before employing it. The ratio of a characteristic associated with a wood-cement composite's property to that of a clean cement paste is known as wood-cement compatibility. A percentage value is frequently used to express compatibility. A variety of factors, including hydration characteristics, strength, the interfacial binding, and morphology, are taken into consideration when determining the compatibility of wood with cement. Researchers employ a variety of techniques, including measuring a cement-aggregate mix's hydration characteristics, comparing the mixes' mechanical qualities, and visually evaluating the wood-cement mixes' microstructural qualities. The most practical approach has been determined to be the hydration test that measures the change in hydration temperature over time. From the Roman era until the early 1900s, bricks were set in lime mortar. Later, Portland cement mortar took their place. Cement blocks are occasionally coated with a parge layer or filled with grout.

3) Concrete

Aggregate and a binder, like cement, are combined to create concrete, a composite building material. Portland cement concrete, which is made up of water, Portland cement, and mineral aggregate—typically sand and gravel—is the most popular type of concrete.

Following mixing, the cement hydrates and finally turns into a substance that resembles stone. This is the substance that is meant to be understood when the term "concrete" is used in its general sense.

Because concrete has a relatively low tensile strength, steel rods or bars—also referred to as rebars—are typically used to reinforce concrete constructions of any size. We therefore call this strengthened concrete reinforced concrete. A vibrator is used to remove any air that has been entrained when the liquid concrete mix is poured around the ironwork to minimise air bubbles, which could undermine the structure. Concrete's durability, formability, and portability have made it the most popular building material in the modern era. Concrete forming and other building phases (insulation installation) are combined in recent innovations like insulating concrete forms. Every item must be consumed in the specified amounts as per the criteria.

4) Fabric

All around the world, nomadic people prefer to live in tents. The circular yurt and the conical teepee are two popular varieties. With the advent of synthetic materials and tensile architecture, the tent has become a prominent building technique once again. Contemporary structures can be supported by air pressure, a system of internal or rigid steel wires, or flexible materials like fabric membranes.

5) Foam

Lately, structural elements like concrete have been combined with synthetic polystyrene or polyurethane foam. It is a great insulator, lightweight, and pliable. Typically, foam is utilized in structural insulated panels, where it is positioned between insulating concrete forms and wood or cement.

6) Glass

Both an industrial technique or material and an art form are associated with glassmaking.

Since the creation of glass, clear windows have been used to conceal minor gaps in buildings. Glass windows allowed people to keep bad weather outdoors while yet allowing light into their rooms. Glass is often created in a kiln, which is a very hot fire stove, using mixes of silicates and sand. Glass is extremely brittle. Additives are frequently included into the mixture to create glass with different hues or features (like lightbulbs or bulletproof glass).

In contemporary society, using glass in architectural structures has grown in popularity. Glass "curtain walls" can be utilized to span over a vast roof structure in a "space frame" or to cover a building's whole facade. But for these purposes, glass needs a frame of some kind to keep portions of glass together because glass on its own is too fragile and would need to be fired in an excessively large kiln to span such vast expanses.

The invention of glass bricks dates to the early 1900s.

7) Gypsum Concrete

Fiberglass rovings and gypsum plaster are combined to create gypsum concrete. Although plaster and fibrous plaster have been used for a long time, particularly for ceilings, serious research into the strength and characteristics of the Rapid wall walling system—which uses a combination of gypsum plaster and 300mm plus fiberglass rovings—did not begin until the early 1990s. Worldwide availability of gypsum (naturally occurring and as a by-product chemical FGD and phosphor gypsums) makes gypsum concrete-based building products highly environmentally beneficial. Additionally, gypsum is totally recyclable.

8) Metal

Metal is utilized as an external surface covering or as the structural basis for larger constructions, such skyscrapers. Metals come in a wide variety and are utilized in construction. Metal is employed in most cosmopolitan cities and is a key feature of prefabricated buildings like the Quonset hut. Producing metal takes a lot of human effort, especially when it comes to the huge quantities required for the construction sectors. The main factor preventing metal from lasting a long time is corrosion.

The most common metal alloy for use in structural building applications is steel, which is mostly made of iron. It is resilient, strong, and long-lasting if properly refined and/or treated.

Tin and aluminium alloys' superior corrosion resistance and lower density can occasionally outweigh their higher cost.

Due to its beneficial qualities, copper is a highly prized architectural material (see: Copper in architecture in Fig 5). They consist of a broad range of finishes, resilience to corrosion, longevity, minimal heat movement, light weight, radio frequency shielding, lightning protection, sustainability, and recyclability. Roofs, flashing, gutters, downspouts, domes, spires, vaults, wall cladding, building expansion joints, and interior design components are all made of copper.

Titanium, gold, silver, and chromium are among additional metals that are used. Although titanium costs far more than steel, it can be utilized structurally. Silver, gold, and chrome are utilized as ornamental materials because they are not structurally sound or have high tensile strength.

Fig 5. Copper Architecture

9) Plastics

Any organic condensation or polymerization product, whether synthetic or semi-synthetic, that can be moulded or extruded into objects, films, or fibres is referred to as a plastic. Their name comes from the fact that they have the quality of plasticity, or malleability, when they are in a semi-liquid condition. The heat tolerance, hardness, and resilience of plastics vary greatly. In addition to their versatility, plastics' generally homogeneous composition and low weight guarantee their usage in nearly all modern industrial applications. Because of their exceptional abrasion resistance and chemical inertness, high performance polymers like ETFE have emerged as the perfect building material. The Eden Project biomes and the Beijing National Aquatics Centre are two notable structures that include it.

10) Papers and Membranes

Membranes and building sheets are employed in construction for a variety of purposes. Red rosin paper is one of the oldest building papers; it is known to have been in use prior to 1850 and was used as an underlayment for external walls, roofs, and floors as well as to safeguard a construction site. Tar paper was created around the end of the 1800s and was used for gravel roofing and applications akin to those of rosin paper. Asphalt felt paper has essentially replaced tar paper in usage. In certain applications, synthetic underlayment has replaced felt paper; this is especially the case for house wraps and synthetic underlayment in roofing.

For roofing, waterproofing basements, and geomembranes, a broad range of damp proofing and waterproofing membranes are available.

11) Ceramics

The use of fired clay bricks dates to the Roman era. Roofing, siding, floors, ceilings, pipes, flue liners, and other applications all require specialty tiles.

C. Living Building Material

live building materials are a relatively new class of construction materials. that are materials that are either made of, or derived from, live organisms, or that behave in a way that is evocative of living things. Materials that duplicate (reproduce) instead of being created and materials that can cure themselves are examples of potential applications.

III. CONCLUSION

Managing materials is an extremely intricate task. It is unclear which material should be utilized in this model to keep costs from rising, and selection of the material should be based on cost. The economic, ecological, social, and energy costs of a material should all be taken into consideration when choosing it. The quality of the construction and its lifespan are then jeopardized if the material is not chosen in accordance with the kind and requirements. Climate claims that in order to prevent the structure from becoming hollow, the material's process needs to be addressed. This paper discusses all of these topics because none of these issues arise.

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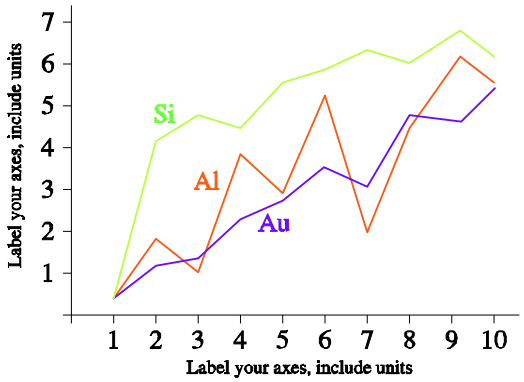

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CONCLUSIONS

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Causal Productions wishes to acknowledge Michael Shell and other contributors for developing and maintaining the IEEE LaTeX style files which have been used in the preparation of this template. To see the list of contributors, please refer to the top of file IEEETran.cls in the IEEE LaTeX distribution.

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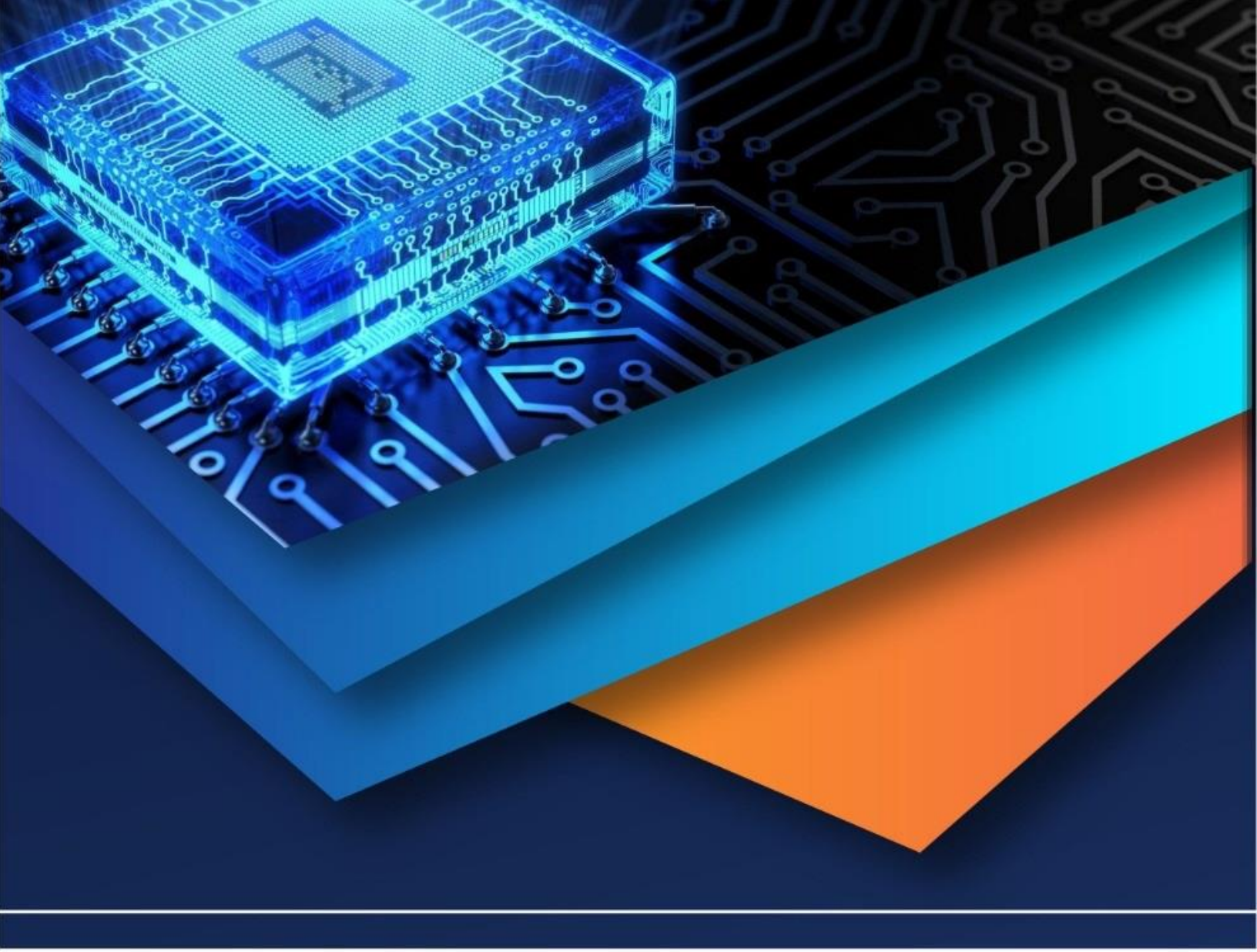

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