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Emerging Trends in Advancement of Formwork

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Abstract: ***The Indian construction industry has grown considerably in the last few decades to meet the housing and infrastructure needs of an increasing population. The entry into the Indian construction sector of multinational corporations has improved the accuracy and pace of work. Conventional methods of construction are cost-effective but cannot generate the work and speed required. There is also a need to focus on emerging construction technology today. Shaping is a significant building factor, comprising approximately 30-35% of total construction costs. Several new technologies are being applied for shape systems that can boost overall economic performance, high construction quality and build speed. This paper analyzes the new on-site shape technology and shows that it is more useful than the previous shape method. In a variety of instances, modern buildings can be very complex, whether on a high-level or horizontally dispersed basis, in scale and size or suitable for sophisticated construction facilities or other requirements. The selection of an efficient shape process includes key parameters such as cost, building speed, quality achieved, cycle time, etc.***

Keywords: Aluminum System, DOKA Formwork, Modular Aluminum formwork, MIVAN formwork, PERI Formwork, Quality, Speed of construction.

I. INTRODUCTION

India is a developing country in the world. The Indian construction industry is the second largest employer in terms of agriculture. Construction industry plays a key role in the country's economic development, impacting GDP growth by 11 per cent (2015). Due to the growing need for infrastructure with an increase in population, the need for efficient technology to develop speed and economy is a focal point. It plays an important role to achieve this formwork method. Formwork is a temporary construction to support structural members during the concrete hardening process to withstand loads such as dead load of wet concrete, hydrostatic pressure of concrete and living loads due to labour and machinery, sudden effects load due to vibrators, pouring of concrete and due to equipment operation etc.

While the formwork supports structural members and loads, it should also offer a smooth and quality finish. As for the building industry, the point of view is very strong. The formwork is an important element in building. With the advance of recent technology, conventional formwork is replaced by acceptable material based on cost, time, quality of construction, waste generation and protection during the work process. Ease of Use Given the rushing rate of construction, a traditional architecture solution is totally inadequate to the mass housing industry for individual buildings featuring load bearing walls with an installation roof over them or reinforced cement (RC) constructed base construction with retained walls. However, these buildings are often susceptible to poor quality assurance, except with builders with substantial resources and experience.

"It’s crucial that innovative technology is able to evolve rapidly to have a high-quality, functional framework that provides cost-effective affordable housing"

In different countries around the globe, a range of programs are implemented; eventually, in India, comparatively expensive and easily managed systems are useful. Some solutions are in fashion, and increasing numbers are seeking to introduce new technology. The architectural design, i.e., pre-cast construction or in situ architecture, is basically the foundation for both.

The most basic component of the building is the formwork. Formwork is a mold or matrix pattern in which fresh concrete is poured and supports the concrete to its hardened state. In particular, there are two types of support which are horizontal support and vertical support. Formwork carries all sorts of loads, such as dead loads, live loads, etc. Formwork is a temporary framework that gives the structure the requisite shape and dimensions. Vertical type of support is known as shuttering and horizontal type of support is known as shuttering. Centering such vertical and horizontal supports shall be supported by staging in the form of bellies, props and jacks.

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II. LITERATURE REVIEW

These literature reviews are experimental work carried out by researchers on the bases of various selection criteria of formwork, various case-studies and by experimenting their calculation on different formwork techniques for cost-effectiveness.

A. Critical Literature Review Based on Usage of Conventional and Semi-conventional Techniques in Construction.

Table I
Examples of Research On The Impact Of Using Conventional And Semi-Conventional Techniques

Methods in use	Source	Observed changes
Conventional and Semi-conventional method	Can Balkaya et al. (2004)	Studied rendered Reinforced Concrete model in a multistory and put a high stress concentration on it, they claim that the outer shell of the monolithic framework had a shear wall from experimental finite element approach (FEM analysis); it was less prone to cracks in the building. Compared to traditional construction, they offer the highest seismic efficiency at a low price.
Conventional using special design method	Nuzul Azam Haron et al. (2005)	Price research was carried out with the old method and the new formwork framework. It allows you to realize that the conventional and monolithic form is simpler and faster. Interview questionnaires and case studies were used to collect study results. The mathematical 't-test' showed that the expense reduction for conventional design systems varied greatly from the form system.
Conventional method	H. Gonzales et al. (2011)	Addressed the seismic survey was also completed in Peru of seven existing shear walls and typical high buildings. Static and fluid nonlinear analyzes have been performed with specified bodies. The seismic performance of all measured installations was considered to be insufficient. The first move is to avoid failure of the binding belts. Any of the feasible beam modifications, therefore improve the seismic performance.
Conventional method	N. H. Abdul Hamid et al. (2012)	Studied joint slab-wall performance in RC wall construction at lateral loading. It prepares a blade model, and with linear potential meters and actuators, it is deduced that, after 2.1 percent drift, the stiffness of the blade joint falls from 0.2 percent drifting to 2.1 percent drifting.

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B. Critical Literature Review Based on usage of Modern-day Techniques in Construction

Table II
Examples of Research On The Impact Of Using Modern-Day Techniques

Methods in use	Source	Observed changes
Conventional and Specialized methods (DOKA, PERI, RMD, etc)	Arbaaz Kazil et. al (2015):	Studied that plastic shape seems to be a best way to build, while DOKA, PERI, RMD, etc. seem to take less time, but the overall cost is extremely high and, for some cause, a work stoppage in India, where there are a lot of difficulties involved, has an important impact for production bags. For this study, the technique of Mivan shape was not taken into account, as its initial cost is extremely high. Recent research has also shown that Mivan shuttering is only cost efficient when used in projects for mass housing. Criteria such as cost, performance, construction speed etc., were agreed on, but questions such as security, uncertainty, site restrictions and constraints must be thoroughly investigated to give a full picture of reality and to be thus more exact.
Conventional and precast methods	H. G. Vivek prasad et al. (2015)	Study of conventional construction methods, pre-cast and monolithic. The competitive considerations are mostly building materials and the required period, costs involved when the construction of the mass housing is designed using traditional precast and monolithic methods. Curing development costs and reducing the average time required to build the project are current and innovative methods developed. For conventional processes, the best approach is short distance construction of monolithic and prefabricated frameworks.
Aluminum methods (MIVAN)	Sanket Sanghai et. al (2018)	Explained construction is one of the main industries and an important part of the Indian economy. It is also an important parameter in the development of the country. India is desperately preparing for the rapid development and formation of housing units for economical construction facilities. Formwork facilitates the construction and construction of essential elements and components of any construction facility needed to be strong and efficient in the management of the structure. In contrast, for the successful completion of an especially repetitive mass project Mivan is developing a new construction technology. The cost and time of comparing Mivan technology with conventional coining technology were discussed in this paper. Mivan technology is useful and efficient with cost, quality and time savings compared to conventional technology. The technology of Mivan is important. The underlying philosophy is that the two methods be equivalent to each other.
Specialized methods (MIVAN)	Rashmi J. V. et. al (2020)	Different mold structures provide a broad spectrum of good designs that can be selected to satisfy the particular innovation requirements. Daily prelude to solid, historically personalized innovations. You need talented professionals. Such shapes often had low protection and a modest rate of growth and huge amounts of waste – counterproductive and unsustainable. Present shaping systems are designed for acceleration and expertise, which are normally separated. They are configured to improve precision and minimize output waste and to improve many of the operation's excellent quality and safety features. It is based on the above-mentioned knowledge analysis. Mivan production needs less time and costs to grow fully. There is currently no pre-requisite for divider installation, and aluminum shaping would provide a better finishing surface. It is much better than typical brickwork manufacturing.

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C. Major Finding from Literature Review

According to above literature review there are many points, that gave the focus on the era of modern-day formwork using other countries and making speed, efficient, economical and indulging with fast-track techniques of construction. Major findings from above are listed below: -

1) The materials and methods used to erect the new shape structures in India have been investigated.
2) Modern form systems implementation in India.
3) Recommend to the Indian construction industry the best formwork system that complies with prices, quality and safety specifications.
4) The danger to the ecosystem was established by the use of local conventional shaping systems.
5) The delay in the use of modern formwork systems in local building practices was studied.
6) It suggested the cost savings process in local building activities by using current formwork systems.
7) Identify the actual local form costs and evaluate the percentage of labour costs and the material costs of cast in situ concrete formworks.

III. FORMWORK

It is made from plastic, like concrete is built. Before it is sturdy enough to hold its own weight, temporary support is required and castings of the correct type. This partial covering is called a shuttering or shuttering. The word moulds are often used to define the structure of very limited units, including lintels, cornices etc.

A. Definition of Formwork

"The receptacles that concrete is put into and cured are the forms of shapes of shutters that it should have perfect form or contour. Once concrete achieves the power it requires to bear its own weight, it may be withdrawn."

"Shape is the term offered to temporary or permanent moulds that have been moved into concrete or related matter."

The basic formwork and/or shuttering specifications are:

1) It should be strong enough in construction to carry the dead and living loads.
2) The joints of the shaft should be secure to prevent bulging, curvature or shrinkage attributable to dead and live loads
3) Coating design would require removal the different pieces without harm to the concrete in required sequences.
4) The formwork material will be inexpensive, readily accessible and reusable.
5) The outline should be exactly matched to the target line, and the dimensions should be smooth.
6) So much as light can be.
7) Once exposed to water, the substance of the shell will not be bent or blurred.
8) Will sit on a strong basis

B. Types of Formwork

Wood is the most popular wood used to date. The use of alternative materials such as furnace and steel, however, has been popular due to the diminishing forest stocks and the increasing cost of timber. In recent years, products such as plastics and fiberglass are increasingly used for pre-molding shape. The material type to be used depends on the building's complexity as well as the quality and cost of the material. For the usage of a particular formwork material, the project limitations as overall cost, completion times are often of great significance. Fig. 1 and 2 shows the typical structure of wooden and steel formwork, respectively.

1) Timber Formwork
2) Steel Formwork
3) Plastic Formwork

Fig. 1. Wooden Formwork

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Fig. 2. Steel Formwork

C. Aluminum Formwork (MIVAN)

Aluminum forms are identical in many ways to steel types. However, Aluminum forms are lighter than stainless steel because of their lower density, and this is its main advantage compared to steel. Since the resilience of Aluminum is smaller than that of steel in storage, stress and strain, wide parts may be utilized. When a huge amount of reuse is rendered in building, the shape is economical. The biggest drawback to Aluminum forms is that when the formwork is formed, no modifications can be made.

D. MIVAN: - A Versatile Formwork

MIVAN is widely used for community and social housing initiatives. The Aluminum-shaped system is the most significant. Simple, easy, scalable and cost-effective. This produces research of absolute coherence, which needs minimal upkeep and where the primary concern is reliability. This tool is suitable for the Indian climate as a tailor-made Aluminum shaft for the cast-in building. Fig.3 shows the typical MIVAN formwork system formation and whole structural unit. Fig. 3. Showa typical MIVAN system.

Fig. 3. MIVAN Formwork System

E. Background

MIVAN is actually an Aluminum shaping tool designed by one of Europe's manufacturing corporations. In 1990, MIVAN Company Ltd from Malaysia started producing such formwork devices. Currently, there is demand in the world of more than 30 000 square meters of coating. There are numerous buildings in Mumbai, India that have been designed using the above method and which have proved very economic and successful for the Indian construction climate. In many countries such as Europe, the Gulf Nations, Asia, and other parts of the world, this system is commonly used. MIVAN is an effective method for constructing vast numbers of houses in a short period, utilizing room form in a single continuous concrete to construct walls and tiles. Curing/curing materials from hot air can allow for the early removal of forms. It's quick constructing, two flats a day say. All processes are formulated in the fashion of a line of construction, which means that output is reliable, managed, and of good quality at the highest expense and as soon as feasible.

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It designed design system includes continuous shielding of the building foundation of built-in concrete walls and monolithic floor slabs. Wide space systems for walls and floor plaques are installed on location. Such forms are rendered solid and robust, correctly crafted and simple to handle. They have several repeats (approximately 250). The concrete is produced in RMC batching plants and is shipped to the transit mixer factory, under strict quality control.

Before concreting in the process, the windows and door frames and service pipes are mounted. Structure often involves staircase steps, front doors, chajjas and prisons, etc. and all other pre-manufactured pieces. Compared with many conventional building methods, this appears to be a significant benefit.

The building approach used is no different because the sub-structure is constructed using traditional techniques. The super-structure is built using techniques from MIVAN. The combined implementation of the system contributes to a robust framework.

F. Modular Formwork

The form frame is precisely built-in Aluminum. This approach allows for the construction of cast concrete with all building materials, including walls with load bearing, columns, beams, floor slabs, stairs, balconies, etc. This system has a solid finish on the top and good dimensional tolerances. In fact, the construction pace is strong, and the work can be achieved economically. The compact nature of the formwork structure makes for easy installation and removing of the formwork, and the building will proceed quickly with very little difference in dimensional tolerances. The system is still very versatile and can quickly be adjusted to certain style variations.

The procurement of cement from a ready-mix concrete plant is well planned with the implementation of this job process. The usage of Aluminum formwork systems, however, has been improved by plentiful RMC plant in India's cities and the potential to use mechanized transportation and concrete positioning methods. The resulting concrete has a surprising quality.

The structurally stable alternatives were known as the most effective application of the closed box framework with a monolithic concrete design. Beton and steel pressures are shown to be somewhat lower, while the lateral influences of wind or earthquake are paying heed.

The shape system can be used to build a framed structure with beam-slab elements or a structure of the type with a combination of platform walls of all types of concrete systems.

G. Construction Activities with Mivan Formwork

The construction activities are divided as pre – concrete activities, during concreting and post – concrete activities. They are as follows:

1) Pre – Concrete Activities

a) Inventory Delivery on Site: Equipment is provided on site on request.
b) Controversy Thresholds: The lateral stage tests are done.
c) Selection: The outline is changed.
d) Deviation Control / correction: Deviation or other correction is made.
e) Erect Forming: The form is installed on the ground.
f) Form Build Deck: Deck is fitted up for function.
g) Kickers are Mounted: Kickers are distributed over the plate.

After the above activities have been completed it is necessary to check the following:

- Every shape will be washed and painted by a professional artist.
- Ensure that the wall form is matched to the walls. Verify that all openings are of the same scale, not spinning.
- Test all horizontal form (deck sofa, base sofa, etc.) standard.
- Ensure that the deck and beam supports are perpendicular and that the component spans are perpendicular.
- The wall links are tested; both pins and wedges are in place and are secure.
- Some surplus content or objects to be withdrawn from the casting process.
- Ensure a safe connection of the job platform braces to the concrete.

Fig. 4. & 5 represent the pre-concreting work of formwork

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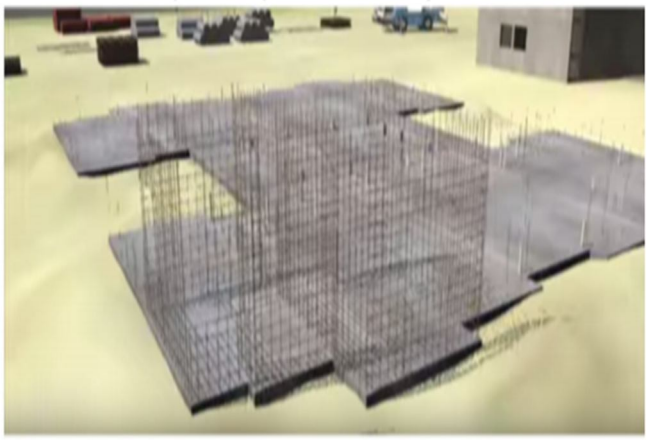

Fig. 4. Pre-concreting

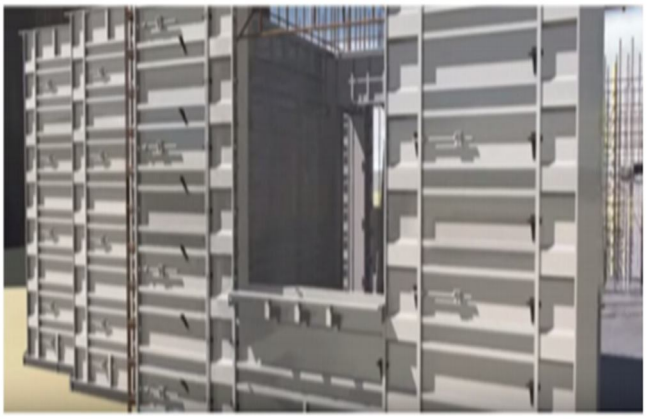

Fig. 5. Placing of formwork

2) *On Concrete Activities:* For pin tests, wedges and wall links, at least two team members will be on hand during concreting while the pour is in progress. Failure to push the shaft and the risk of destroying the shape may contribute to pins, wedges or wall contact. Once the surface has been compromised, this – contaminated region would also need remediation. Fig.6 includes the on-concreting process. Things to look for during concreting:

a) Unloading of acceleration pins / wedges.
b) Beam / deck supports next to vibration-related drop-offs.
c) Ensure that all bracing is vibrated in special areas.
d) Excess asphalt at the bottom of the doors etc.

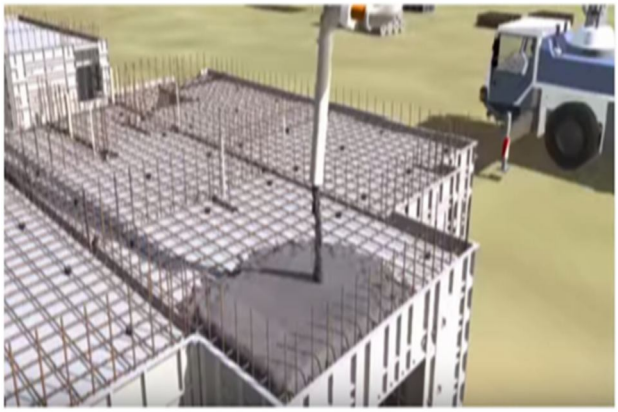

Fig. 6. On Concreting

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3) Post – Concrete Activities

- Strike Wall form-The wall form is important.
- Strike Deck Type- The outline of the deck shall be withdrawn.
- Clear form, transport and stacking
- Kicker Strike Shaped – Removed the kicker.
- Strike wall – The wall is fitted to the next floor on a work platform.
- Erect frame – the job platform is set up on the mount and the roof.
- Normally all formwork can be struck after 12 hours.

H. PERI Formwork

With over 70 subsidiaries and over 140 logistics centers PERI continues to set standards in the industry as world's largest manufacturer and supplier of formwork and scaffolding system. PERI India celebrates its successful journey over a decade and continues to build a strong customer base by offering distinct solutions for every construction need.

With rapid urbanization, more and more high-rise structures and infrastructure development will be seen across India. With implementation of RERA and Government impetus on infrastructure, there is streamlining in construction methodology and rush to complete project in time. Modern construction demands technologies that are faster, safer and more innovative.

PERI India has expanded its foot prints across all construction sectors. With landmark projects such as Mahatma Mandir, Statue of Unity, ITPO, Surat Diamond Bourse, Bengaluru Metro and Hyderabad Metro using state of art formwork and scaffolding system, we have proved our mettle in delivering customized solutions for every complex need, and in most cost-effective manner.

I. DOKA Formwork

Doka is an international producer and supplier of formwork used in all fields of the construction sector. It is a branch of the Umdasch Group AG based in Ramstetter, Austria. Doka has a worldwide workforce of 7,400, with 160 branches in 70 countries. Listening intently, understanding the world as seen through the eyes of our customers, learning to understand all aspects and thinking ahead. We are passionate about not being satisfied with the first solution that might get the job done. Rather, we continue fine-tuning it until we come up with a true advantage for our customers. This is the only way a small woodworking shop could grow into a globally operating formwork company known by the brand name Doka since 1956

Giving construction firms professional advice and support 'on the spot' is a core competence of Doka's. With more than 160 sales and logistics facilities in over 70 countries, Doka has a highly efficient distribution network to ensure that equipment and technical support can be provided swiftly and professionally – no matter how big and complex the project.

Fig. 7. Benefits of Modern-Day Formwork

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IV. COMPARISON OF ADVANCED FORMWORK SYSTEM WITH CONVENTIONAL CONSTRUCTION

The definition demonstrates the relative difference between typical systems and the MIVAN style feature method. This distinction is based on aspects such as construction speed, construction efficiency, design, exterior finishes and maintenance.

A. Speed of construction

Construction pace is often slower when various phases of the construction are slowly finished, such as outline forming, concretion and shuttering, and eventually plastering and finishing. This approach allows for walls and floors to be cast continually, so the finishing work will then commence instantly, and the speed of construction is considerably higher.

B. Quality

Thanks to the conventional construction method, uniform production is obtained. In-situ construction of the entire frame and transverse walls in continuous service achieves superior performance.

C. Aesthetics

The controversial walls are made of bricks in the case of traditional architecture, which cause the column and the beam to reveal a gloomy plot in the house. Through the MIVAN system it is easy to co-plant the partition wall and ceiling elements, since the interior is clear and flat, without awkward projections through various corners. There's even a seamless layer between the roof and walls.

D. External finishes

Also, the external walls are made up of bricks, which entail frequent repainted manual cement plastering. The outside walls are made of concrete and require no manual cement plastering and even smooth finish, so it is not important to rebuild them annually.

E. Maintenance

The upkeep expense is too high as the wall, and ceiling plaster were constantly cleaned, the outer and inner walls are stained with leakage. The maintenance costs are low, as walls and floors are constructed of good quality concrete and need to be repaired frequently.

V. ADVATAGES AND DISADVATAGES

A. Advantages of Specialized Formwork are:

1) The surface of good quality achieves dimensional continuity.
2) A high-quality concrete finish for precise tolerances and verticality is created while extracting a mold.
3) The full concrete systems are created by the entire method.
4) Customized to satisfy the needs of the client.
5) Unmatched construction pace.
6) Up to 250 times panel may be reused
7) Using professional labor may be installed.

B. Advantages of Specialized formwork over conventional formwork:

1) It retains greater seismic tolerance.
2) By comparison to traditional brick bat mazing, a full cement framework is more robust.
3) The walls are thin and thus expand in the region of the tapestry because of the shear walls.
4) Thanks to the light weight of designs, unparalleled production speed can be accomplished.

C. Disadvantages of Specialized formwork:

1) In the asphalt surfaces are shown attributable to a few limited sizes following sections.
2) After the completion of the facilities, the limited range of the pieces renders things slightly challenging.
3) The cost-effectiveness of standardized configurations and even elevations are needed.
4) Specialized form requires the amount of wall tie-ups, spacers etc., causing drainage issues and monsoon leakages.
5) Compression breaks are usually due to box style creation.
6) High hydration heat is generated because of shear walls
7) Once in position, the design becomes inflexible, and all modifications become severe later.

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VI. COMPARISON

Thus, from the literature review studied and all review done, the points of comparison which came out that are listed below in the table:

Table III
Comparison between Conventional Methods And Specialized Method Of Formworks

Sr. No.	Parameters	Conventional Methods	Specialized Methods
1	Initial Cost	Comparatively Low	Comparatively High
2	Scrap Value	Higher	No scrap vale
3	Repetition	25-30	150-250
4	Type of construction	Simply RCC-framed construction	Cast-in-situ cellular construction
5	Cycle time for casting typical floor area	Varies from (15 -25 days) *	Varies from (10 – 17 days) *
6	Durability	Lower	Higher
7	Surface Finishing	Fair	Smooth#
8	Accuracy	Not as much	To a great extent
9	Aesthetics	Not Superior	Superior
10	Water Resistance	No	Yes
11	Manpower Requirement (in no.)	Most required	Less required
12	Manpower Requirement (in skills)	Requires skilled and unskilled manpower	Semiskilled manpower can be employed
13	Training Programs	Not Relevant	Relevant
14	Planning System	Not Required	Required
15	De-shuttering	Hard	Easy

*depending upon various site condition
#Smooth in level of not requirement of plaster

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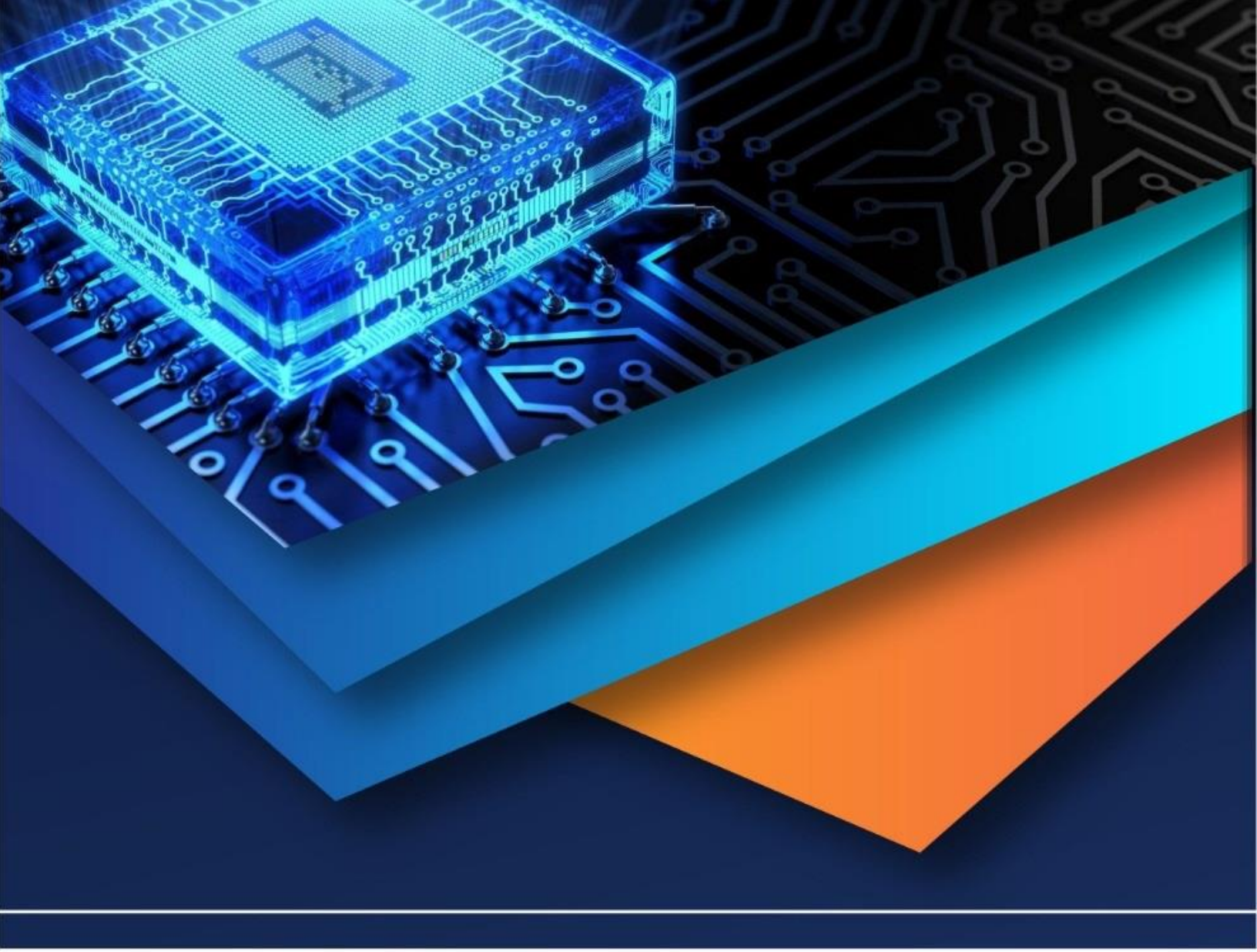

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