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Challenges Faced in Prefabrication or Modular Construction

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Abstract: ***The prefabricated materials used in construction has indeed been hailed amongst the most efficient approaches, there is a difficulty in implementing this process in the construction industry. The article included an outline of the obstacles and factors that influence prefabrication or modular construction in India. The issues of prefabrication and modular construction were investigated through case studies. Prefabricated elements have been demonstrated to be an efficient and efficient approach for improving productivity and the process of construction, as well as assuring the quality of construction & reducing time and cost. However, there are a number of issues with this strategy in practise, including initial high building costs, lack of understanding of the prefabricated method of construction, technical and installation hurdles, and the inability to find prefabrication businesses locally. Because of the nature of the city and also the growing population, the use of such prefabricated materials in the construction of buildings is beneficial.***
Keywords: Prefabricated construction, Challenges, fabricated elements, Installation hurdles

I. INTRODUCTION

The shifting of building activities first from field to an off-site manufacturing facility is known as prefabrication (Tatum, 1986). Furthermore, factory output and trash generation can be reduced, and recycling construction debris can be encouraged, resulting in the protection of environment and industry sustainability (Hendricks et al., 2000). Prefabrication is a waste-reduction technique that is widely used (Bell, 2009). Weather control, enhanced form of labour supervision, quality control, fewer material deliveries & easy access of tools are all made possible by prefabrication (Goulding et al., 2013).

Prefabrication improvises the safety of workers by reducing exposure to severe temperatures, bad weather, ongoing or hazardous operations; it also improves the conditions of working environment. Though amongst the most effective method for mitigating waste seems to be the usage of prefabricated materials in building.

Transportation of prefabricated elements / components, for example, are some of the other causes. Manufacturers' failure to produce elements at the time they are needed, dimensioning, or quality errors, Manufacturing, are all examples of manufacturing errors. Joint leakages, quite often in the prefabricated elements of concrete, unavailability of most essential machinery, labourers' lack of experience with this way of building, and clients' lack of awareness of this particular construction methods. These, as well as a slew of other issues, arise as a result of such implementation of such construction techniques.

Moreover, this research is important to the building industry since it provides more information on the issues that construction businesses experience while utilising the methods of prefabricated construction. This then discloses towards the industry new ways to adopt this style of building for more successfully completing projects at improved fewer people on site, site safety, low rates, & many other advantages accessible when such implementation of the construction methods.

Prefabrication also reduces the need on the site preparation of skilled trades, construction projects, plastering, carpentry, bricklaying, joinery, ceramic tiling, and other trades by requiring just in-situ assembly (Gibb 1999). For many years, prefabrication, or off-site construction and then assembly of on-site & transportation, is being used for the structures of residential superstructure (Yu et al. 2008; Poon & Jaillon. 2009). In most industrialised countries, significant developments in the construction and design of superstructures had also greatly increased the number of prefabricated buildings erected. To ensure the resilience of superstructures, the prefabricated elements safety measures has also been researched globally (Friedman 1992).

II. REVIEW OF LITERATURE

Prefabrication and work simplification in the building industry are really not new notions; they have been debated extensively although since 1950s (Branson TR et al., 1990). For many years, extensive applied prefabrication has been employed all over the world. Prefabrication is a term that has a variety of meanings, but it mainly refers to the offsite fabrication of buildings, or portions of buildings, prior to onsite installation or assembly (Gibb G F et al., 2007; Blismas N et al., 2006).

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Pre-assembly, modularization, prefabrication, industrialised structures & system building, are all names that are regularly used to characterise this type of construction (Manley K et al., 2013). Although the technology of prefabrication produce a better product in a quality-controlled, the construction industry, sheltered environment will inevitably migrate toward more prefabrication. This is regarded as the one of the tenets of improvement of construction industry of 21st-century (Egan J, 1998; Yeung N S Y et al., 2002), Modular, Complete, Panels & Pods, are examples of the prefabricated elements used throughout the prefabricated buildings construction, and they cover structural buildings modular units, pods, panels, and totally prefabricated buildings (Bell P, 2010; Isack F et al., 2003). The researchers focused at a theoretically structured framework developed by (Gann D M et al., 2000). Prefabrication of structures is seen as the product of a 'open innovation system,' according to the framework (Appleyard M M et al., 2007). This method allows for a better understanding of such broader influences that may facilitate the prefabrication choices (Salter A J et al., 2000). An 'open innovation system' can be examined using a product framework based on projects. Building businesses, regulatory authorities, end-users & suppliers, must be seen as partners in a wider form of network working toward a similar goal, rather than as isolated actors working in isolation (or "silos") (Rothwell R, 1994; Borenstein D et al., 2001; Gassmann O et al., 2006; Zainul Abidin N, 2010). From the implementation of the builder level challenges practically to 'soft' concerns like safety and health, process issues, & management, there is a need for a holistic examination of the benefits and drawbacks of using the prefabricated elements (Blismas N et al., 2005). Prefabrication is chosen in this study, with a focus on the components of building that are manufactured off-site in a factory. In comparison to the permanent sector, such form of sectors have higher adoption rates. (Aburas H, 2011).

As a result, the present study comprehensively analysed the existing evidence regarding the potential barriers or challenges of prefabricated elements in building construction, with a focus on the challenges to solve the cause for this method's restricted application.

A. Improving Construction Productivity

The construction industry faces a big challenge in improving efficiency in this age of production efficiency (Bertelsen, 2004). The construction industry's unique production characteristics resulted in low & waste productivity, variability, customer value performance (Vrijhoef and Koskela, 2005). According to Gann (1996), the construction company must take note of the manufacturing industry's increased productivity, Henry Ford took advantage of efficiency gains in the manufacturing business by mass producing automobiles (Lamming, 1993). As a result of Ford's motivation, Taiichi Ohno on later devised lean manufacturing (Womack et al., 1990).

The problem of increasing the productivity of construction should be centred on optimising flow and value generation, as suggested by lean construction (Bertelsen, 2004). Bertelsen (2004) also noted that in order to solve productivity issues, two main strategies emerge: minimise on-site construction variability and complexity, or develop new systems for the control & management of construction. In contrast to the typical one-off project strategy, Turin (2003) suggested three alternative approaches: model approach, process approach & component approach. The component method is linked to the mass manufacturing notion and implies a component-level repetitive logic (Vrijhoef and Koskela, 2005).

The benefits of prefabrication could be classified into three groups: a) economic, environmental, & social viability (Bhattacharjee et al. 2016). Lower construction costs are among the economic benefits, while greater labour productivity is among the social benefits & reduction in the working hours of construction labours, and the environmental side includes benefits such as reduced rework due to reduced material waste. The advantages of modular construction approaches over traditional construction methods, according to Jaillon and Poon (2008), are significant. In addition, the modular building method reduces waste on the job site (Tam et al. 2007).

Based on building site location, client and planning requirements, the modular construction technique & form factor, may be a superior option (Gorgolewski et al. 2001). (Gorgolewski et al. 2001, Pan et al. 2007; Jaillon et al. 2009, Bhattacharjee et al. 2016,) Some instances in which it would be preferable over traditional construction approaches include:

1) Building shapes that are cellular or regular with such a higher degree of repetition, allowing for manufacturing & design on economies of scale.
2) In Construction sites wherein noise and various other pollution must be carefully controlled during the construction phase,
3) Additions to existing structures and
4) Future extension or relocation of construction projects.
5) Construction in congested cities.

According to an assessment of the literature, modular building has numerous obstacles and challenges. Skills, experience, motivation, culture, equipment and standards, & cost a market for a new way of building, interface, adaptability, industry, and projects, for example, are all listed as impediments by Rahman (2014). Furthermore, the following is a project for modular construction:

a) High initial investment required (Pan et al. 2011; Jaillon and Poon 2010);
b) High-skilled labour is required. (Pan et al. 2011; Jaillon and Poon 2010,);
c) There is no standardisation in design. (Pan et al. 2011; Nadim and Goulding 2011);
d) Possesses a limited demand in market (Pan et al. 2011);
e) It is necessary for all involved parties to communicate effectively. (Salama et al. 2018);
f) Lacks experienced contractors in applying modularization concepts (Salama et al. 2018);
g) Parts and modules must be designed and manufactured early in the process (Wong 2000); and
h) It has a significant transportation cost for delivering larger modules to the job site. (Pan et al. 2011; Poon & Jaillon 2010,).

B. Complexity and Uncertainty in Construction

The inherent complexity and uncertainty elements are the key restrictions affecting the outcome when focussing on the resources required to execute a task and the environment in which it is completed (Gidado, 1996). A complex process has been defined in various ways by several academics. Perrow (1965), for example, defines the task complexity as the complexity level in the task's search process, the amount of knowledge required to complete the task & the time required to answer difficulties. According to Thompson (1981), complexity is defined as the difficulty in coordinating a manufacturing process, which includes activities that are not standard. According to Malzio et al. (1988), a complex process is made up of inventive activities carried out in an uncertain environment. Furthermore, a process that has operations that aren't well-defined or lack requirements should be considered difficult (Malzio et al., 1988). The number of parts and their interactions, according to Gidado (1996), determines the complexity of such a process, the difficulty of understanding or carrying out the task, and the resources used in the process. According to Hill (1991), the number and diversity of activities required in a process of production make it complex. The complexity of a process appears to be determined by (1) the number of sections engaged in the process and how they interact; (2) the difficulty degree in carrying and understanding out all the tasks; (3) the familiarity and ambiguity of such environment; and (4) the variety & number of activities in the process.

As per the Dr. Anoop K, M Krishnanunni, the technology of Prefabrication is an ideal solution for the conventional form of construction methods, according to the study, because of its social, technical, sustainability & economic features. construction techniques of prefab have proven to be a much more viable solution than existing conventional methods as a result of recent advances in technology and design, as well as increased emphasis in the sector of construction to address social, technical, sustainability & technical issues. Most advanced countries have already embraced prefabricated construction and are reaping the benefits. However, as with any technology, prefabrication has a poor adoption rate in the building industry, particularly in the countries with emerging and underdeveloped status. The aim of this paper to provide an overview of the challenges facing India's construction business, as well as the housing situation in the country and in the state of Kerala, with a focus on how the technology of prefab can help to address these concerns by highlighting its benefits.

Mrinal Neskar and Ashish Ugale discuss the profitability implications of technology and equipment of prefabrication. Prefabrication is the process of fabricating and pre-assembling components, parts or modules before they are installed in their ultimate location. Any country's construction industry relies heavily on the prefab industry to generate new concepts. In today's world, there is a great demand for the houses. As a result, it must be completed at a faster rate while keeping costs low. Traditional building, on the other hand, is incapable of achieving speed. As a result, we choose to build using alternative ways. One method for reducing total construction time is to use precast concrete. Although there are benefits to precast building, such as reduced construction time and ease of erection, there is still scepticism in nations like India about accepting the technique.

III.CHALLENGES

A. Manufacturing Requirements

In order to build an optimal prefabricated solution, it is difficult to strike a balance between structural integrity and affordability. Optimised manufacturing, a systematic approach of reducing material consumption and disposal of waste , could be a key to achieving this goal (Dilanthi 2015). Optimised manufacturing not only lowers costs by reducing usage of material & waste, but it also improves the quality of the final product and increases process efficiency (Standards Australia 2016; Monash University 2017).

To get the most out of a well-designed prefabricated substructure, it's critical to think about production procedures early on. It has been established in previous studies that an optimized philosophy allows for successful manufacturing, assembly & considerations of designs (Stehle & McFarlane 2014). The optimisation methodology allows for manufacturing under-regulated factory circumstances, resulting in more efficient and safe on-site assembly of footings of prefabricated element (Yu et al. 2013).

B. Handling and Transportation Requirements

The ideal prefabricated substructure is safe and simple to handle (Victorian Legislation, 2007, 2004; Australian Government 2011) and transport (Commonwealth, 2011; Brassington 2012; Sebastian 2013). Prefabricated solutions bring new considerations to the handling and shipping of goods (Beck 1999). Lifting of prefabricated elements (Standards Australia 1986), packaging (Australasian Procurement and Construction Council 2014), transportation load restraints (National Transport Commission, and Roads and Traffic Authority of New South Wales 2004), safe containers (International Maritime Organization 2013), and proper documentation are among these factors to consider. The dimensions of prefabricated footing systems may be limited due to transportation constraints caused by vehicle size. Additionally, crane weight constraints and site access should be considered (Monash University 2017).

C. Assembly requirements

The following are the primary challenges of a prefabricated solution:

1) To get a quick on-site method of installation that is not labour-intensive and

2) Should have adequate tolerance for installation ease.

The assembly of connections utilising connections also must adhere to stringent tolerances and be a perfect match with the elements to be joined (Jaspart and Weynand 2016a, 2016b; Menegon et. al. 2018). Because of reduced construction site congestion and increased efficiency in assembling building components, prefabrication results in the reduction of 10% in the expenses of installation labour (Sullivan and Dye 2015). Furthermore, through optimising construction & design processes in a construction project, prefabrication seems to have become a global scale technique to reduce the costs of construction and increase return on investment (ROI) (Gil et al. 2005; Eastman and Sacks 2008).

IV. CASE STUDY 1

A. EPACK PREFAB

EPACK, which was founded in 1999, has grown to become one of the fastest-growing infrastructure companies, specialising in the development of sustainable and solutions for smart building. In the previous 20 years, our products have served a wide range of sectors as well as several major government projects in India, as well as being sold overseas.



Fig.1 Featured Projects



Fig. 2 Featured Projects

B. Applications

1) Prefabricated School
2) Prefabricated Hospital
3) Porta cabins
4) Prefab Site office
5) Workers accommodation
6) Solar Inverter room
7) Multi Storey Building
8) Clean Room
9) Cold Storage
10) Ripening chambers
11) Railway Shelters
12) Prefabricated Pulpits
13) Liftable pulpits
14) Poultry sheds



Fig. 3 Railway Shelters



Fig. 4 Clean Room

C. Challenges

One of the biggest challenges they are facing is the life span of a Prefabricated structure. Life span of prefabricated structure last from 20 to 25 years which is a major drawback compared to conventional construction. Study and research is going on to see if their is a way of increasing the life span of a prefabricated structure.

Prefabrication structures is less water resistant hence there is leakage problem in joints. Due to shrinkage and temperature pressures, fractures may form at the seams between the precast in-place concrete. Extra steel is needed across the joints to overcome them.

V. CASE STUDY 2

A. Sri Raghavendra Services

Our company, Sri Raghavendra Container Services, has been in this field for several years, and our efforts have paid off in a big way, as we've been able to satisfy a large number of customers. Our business is operated as a sole proprietorship. Our amin headquarters are located in Kaladipet, Tamil Nadu. Since 2007, we have been a trader of Security Cabins & leading manufacturer, Office Containers, Bunk House Containers, and many other products to meet the ever-changing needs of our customers. All of our items are carefully inspected by our zealous professionals to ensure that they meet all quality requirements and are packaged in a sanitary manner. We also provide rental services for office containers.

B. Challenges

One of the most significant obstacles they face is the industry's lack of expansion. Prefabrication is growing at a slower pace than conventional building. The industry is expected to grow significantly due to increased infrastructure development and expansion in the residential and commercial sectors, notwithstanding the lower growth rate.

The transport of prefabricated elements from the factory to the place of action must be planned in accordance with the traffic rules and regulations stipulated by the authority, the size of the elements is often restricted by the availability of appropriate transport equipment, such as the tractor to adapt to the load and dimension of the member. Transportation is another big challenge faced in prefabrication.

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Fig. 5 Cabin



Fig. 6 Container Site Office

VI. CASE STUDY 3

A. AVJ Precast Compound Wall

In Tambaram, Chennai, AVJ precast compound walls is located. In the year 2019, the firm was founded. This company's main business is compound walls. Traditional Indian brick walls take a long time to build and are expensive to maintain. Traditional brick walls have certain drawbacks, which we overcome. Our walls are quick and simple to erect, and they have a lifespan that is practically limitless.

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B. Challenges

1) The transportation of prefabricated products from factories to construction sites is quite tedious task.

2) Transportation from long distance, carrying heavy materials to a narrow congested area is a major problem faced by this manufacturer.

3) Land problem is another challenge faced by this manufacturer. After placing the compound wall there is an issue of land misuse because of the owners.



Fig. 7 Precast Compound Walls



Fig. 8 Precast Compound Walls

VII. OVERCOMING WAYS

A. Government Support

If government can take more interest in prefabrication, by building more prefabrication buildings in India.

1) *Example:* Slum clearance board in tamilnadu can do more projects in prefabrication It would help in the growth and familiarity of prefabrication. The involvement of governments in construction would be necessary for the prefab system to succeed. This could be accomplished by setting up construction factories throughout the country. Prefabricated housing should be a government policy that has a significant impact on the construction industry. They are less time consuming and more cost effective.

2) *Training:* Skilled workers are needed for prefabrication. People should be given training in the field of prefabrication. Training should be provided to educate people more about advantages of prefabrication. Prefabricated construction, unlike in-situ building, necessitates skilled labour both on-site and during the manufacturing process, which necessitates machine-oriented competence both on-site and in the process of manufacturing.

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3) *Leakage:* Even minor crack in concrete can cause water leaking due to capillary action of water. Prefabrication structures is less water resistant hence there is leakage problem in joints. Leakages can be reduced by welding or silicon solutions, water resistant.
4) *Providing wider publicity:* Many people are not aware of prefabrication. People should be provided with more knowledge of advantages in prefabrication. Because establishing a precast yard necessitates a significant investment at initial level, investors in India should publicize the technology.
5) *Perception:* People have a traditional mindset, believing conventional construction is better than prefabrication. This perception should be changed. People should be made aware of all the positivity in prefabrication.
6) *Life Span:* More studies and experiments should be conducted to see whether the life span of prefabrication could be extended.
7) *Transportation Issues:* There are several challenges to consider while transporting prefabricated products from factories to the sites. One is how to make the most efficient use of truck capacity in order to use the fewest trucks feasible, and the other is how and where to reschedule the prefabricated products transportation in order to pay for them later and delivery them securely on time. Transportation problems can be reduced by working efficiently according to schedule and delivering the products with safety as priority. Heavy equipment units are prone to being damaged during erection or shipment, thus the design of the pieces must be accurate.



Fig. 9 Transportation Process

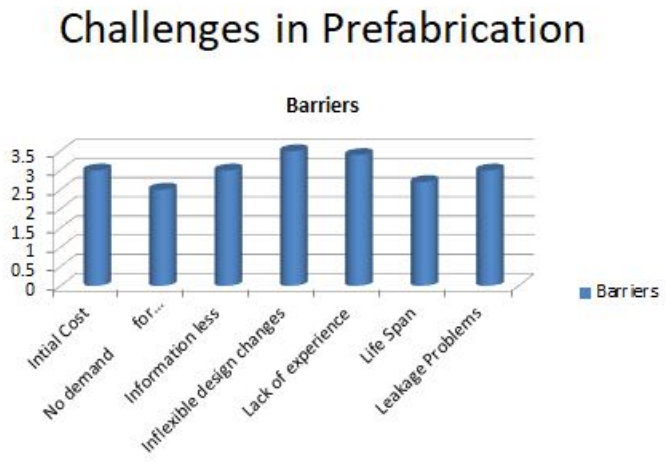


Fig. 10 Challenges in Prefabrication

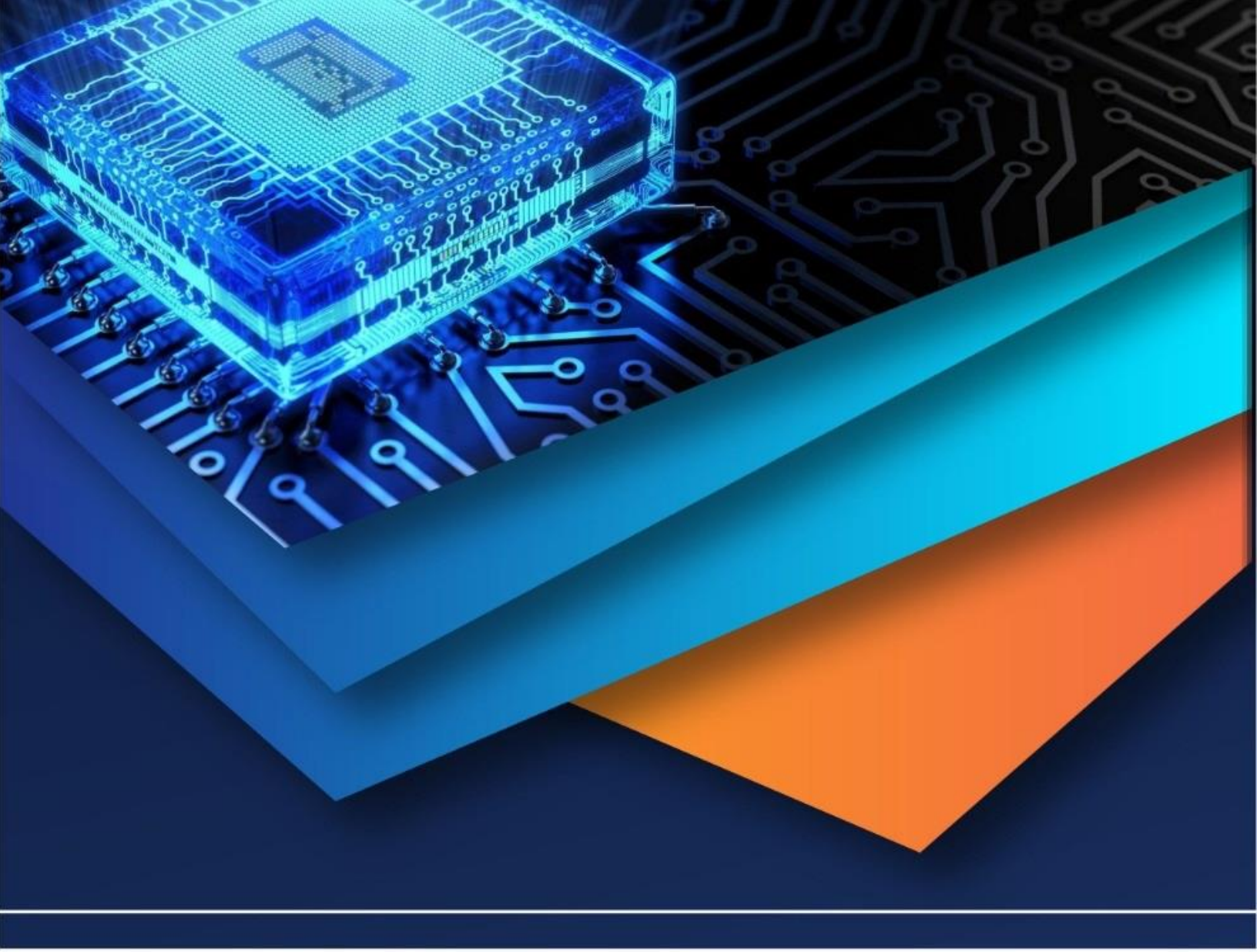
VIII. CONCLUSIONS

By examining the benefits and downsides of today's prefabrication sector, a number of concerns that must be addressed before prefabrication may become the standard can be identified. Increased production volume can be used to offset setup costs for prefabricated manufacturing. Time delays caused by repair complications are unlikely to be significant enough to negate the benefits of prefabricated time gained by bulk production. Making a stronger network for trash recycling and reuse could help solve the sustainability challenge, and increased production also means more money for proper garbage disposal. Mass customisation and site-specific solutions can help overcome design constraints. Finally, global coordination and implementation of safety standards and monitors would be required. Despite the fact that prefabrication is widely used in a range of countries, India's building sector continues to use traditional methods despite its rapid growth. One of the most difficult aspects of prefabrication is this. The facts above are issues faced by prefabrication, particularly in India, as a result of the aforesaid research. We can see the barriers or challenges that prefabrication building faces in India in this study. Despite the fact that prefabrication is a developing business, it nevertheless faces certain significant hurdles. The following research reveals that there are just a few options for overcoming them. However, it may be determined that with sufficient effort, these difficulties can be overcome. Many more technological solutions to the existing issues in prefabrication will emerge in the future.

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