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FEASIBILITY ASSESSMENT OF INDUSTRIALIZED BUILDING SYSTEMS (IBS) FOR PMAY-U BLC HOUSING IN BHUBANESWAR

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Abstract: Rapid urbanization in Bhubaneswar has significantly increased the demand for affordable housing, particularly for Economically Weaker Sections (EWS). Under the Pradhan Mantri Awas Yojana–Urban (PMAY-U), the Beneficiary-Led Construction (BLC) component enables eligible households to construct their own houses with financial assistance. However, conventional construction practices under BLC often face challenges such as delays, rising material costs, labour shortages, and inconsistent quality. In this context, the study explores the feasibility of Industrialized Building Systems (IBS) as an alternative construction approach for improving housing delivery. IBS involves the prefabrication of building components in controlled environments and their assembly on-site, which can enhance construction speed, quality control, and resource efficiency. The research is based on a combination of primary surveys, stakeholder interactions, and analysis of existing BLC housing practices in Bhubaneswar. The study evaluates IBS in comparison to conventional methods across key parameters such as cost, time, construction process, and overall performance. It also identifies practical challenges in adopting IBS, including technical adaptability, initial investment, and awareness among stakeholders. Overall, the study highlights that the adoption of IBS can contribute to faster, more standardized, and sustainable housing development, making it a viable approach for enhancing the effectiveness of the BLC component in Bhubaneswar.

Index Terms **-** Affordable Housing, Economically Weaker Sections (EWS), Pradhan Mantri Awas Yojana–Urban (PMAY-U), Beneficiary-Led Construction (BLC), Industrialized Building Systems (IBS), Precast Concrete Construction (PCC).

1. INTRODUCTION

House is considered as one of the three basic needs of life besides food and cloth. Housing fulfills a fundamental aspect of people's need given that access to safe and adequate shelter and basic service is essential to a person's physical, psychological, social and economic wellbeing. Access to adequate, affordable and quality housing is an important social goal. The need for affordable housing policies arises from the growing disparity between the rising urban population and the availability of housing options that cater to the financial constraints of a significant portion of the residents. Urbanization often leads to increased living costs, making it imperative for the city to provide sustainable and cost-effective housing solutions. Affordable housing refers to housing options that are affordable and within the financial means of individuals and families with low to moderate incomes. The concept of affordability takes into consideration both the

cost of housing and the income levels of individuals or families. Housing affordability could be defined as shelter that is cost-effective, meaning that a household can "pay without financial difficulties".

Pradhan Mantri Awas Yojana–Urban (PMAY-U) is one of the major affordable housing mission launched by the Government of India to provide affordable pucca houses with basic services to eligible urban households belonging to Economically Weaker Sections (EWS), Low-Income Groups (LIG), and other income categories. Among its different verticals, the Beneficiary-Led Construction (BLC) component provides direct financial assistance to beneficiaries for the construction of new houses or enhancement of existing dwelling units on land owned by them.

In recent years, *Industrialized Building Systems (IBS)* have emerged as an alternative construction approach involving the use of prefabricated and standardized building components manufactured under controlled conditions and assembled at the construction site. The conceptual understanding of IBS highlights its potential to improve construction speed, reduce material wastage, minimize labour dependency, and enhance quality control in housing projects. Existing literature further indicates that partial prefabrication systems are more suitable for the Indian construction sector due to local construction practices, labour availability, and socio-economic conditions.

2. PRADHAN MANTRI AWAS YOJANA - URBAN

PMAY-U, being implemented since June 2015, is one of the major flagship programmes being implemented by Government of India under Ministry of Housing and Urban Affairs (MoHUA) to provide all weather pucca houses with basic amenities like toilet, water supply, electricity and kitchen to all eligible beneficiaries in the urban areas.

3. SCOPE OF PRADHAN MANTRI AWAS YOJANA - URBAN 2.0

PMAY-U 2.0 has been implemented from 01.09.2024 to provide Central Assistance to all eligible beneficiaries or households through States or Union Territories (UTs) or Primary Lending Institutions (PLIs) to construct, purchase or rent a house at an affordable cost. It should promote use of resource efficient, climate responsive, disaster resilient, eco-friendly and sustainable building materials, technologies and processes to provide thermal comfort, reduce energy use and environmental impact.

4. BENEFICIARY-LED INDIVIDUAL HOUSE CONSTRUCTION

Beneficiary-Led Construction (BLC) is a vertical of PMAY-U that provides financial assistance to eligible EWS households so they can build their own pucca houses on land they already own or enhance an existing semi-pucca house. Under BLC, the house is planned, constructed and largely managed by the beneficiary, while the government gives a fixed subsidy (typically up to ₹1.5 lakh per house from the Centre, with an additional share of min. ₹1 lakh from the State) released in instalments.

The Challenges associated with BLC Construction are - Slow Construction Progress and Project Delays, Rising Material Costs and Financial Burden on Beneficiaries, Inconsistent Quality and Poor Workmanship, Limited Technical Supervision and Monitoring Challenges, Misuse of Funds and Lack of Financial Accountability, Lack of Standardization and Process Efficiency.

5. INDUSTRIALIZED BUILDING SYSTEMS

Industrialized Building System (IBS), is the process of mass manufacturing sections of a building in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. IBS is closely associated with production of building components in controlled conditions using standardized designs, quality-controlled materials, and mechanized processes.

6. STUDY AREA

Bhubaneswar is the capital city of the Odisha located in Khordha district covering an area of 186 sq km and has been designated as a Smart City. It is the largest city of the state with a population of 8,43,402 as per Census 2011 and has become the center of economic and religious importance in the region. Bhubaneswar is called the Temple city of India, due to the presence of large numbers of magnificent temples and architectural heritage. It has experienced substantial economic growth and industrial development in recent years serving as the home to several IT parks and industrial zones, attracting IT companies, software firms, and other industries. The city has emerged as one of the fastest growing, institutional, administrative, healthcare, tourist and commercial hubs of the state. Rapid urban growth and increasing housing demand, particularly among Economically Weaker Sections (EWS) have led to the implementation of various affordable housing initiatives under PMAY-U within the city. The Beneficiary-Led Construction (BLC) component has been implemented across different zones of Bhubaneswar, making the city an appropriate study area for examining the feasibility of Industrialized Building Systems (IBS) in affordable housing development. The growing need for faster, cost-effective, and quality-oriented housing delivery further strengthens the relevance of selecting Bhubaneswar as the study area for the present research.

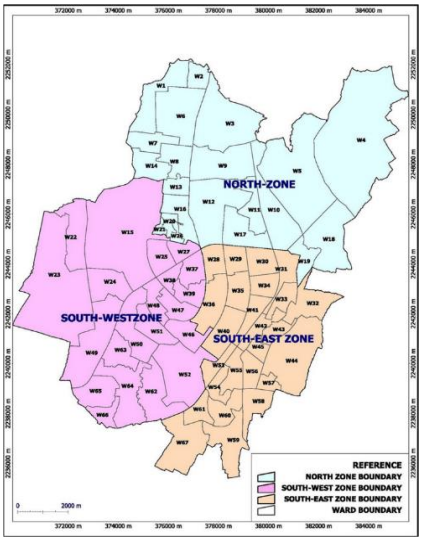

Fig. 1: Bhubaneswar Zonal Map

7. LITERATURE REVIEW

Affordable Housing Options Using Industrialised Building Systems (IBS) by Atul Kumar Biltoria and Uttam Kumar Roy discusses the use of Industrialized Building Systems (IBS) for improving affordable housing delivery in India. It highlights that conventional construction methods are slow and less efficient in meeting increasing housing demand, while partial prefabrication-based IBS can improve construction speed, cost efficiency, and overall project performance for EWS and LIG housing.

Low Cost Modular Housing under PMAY by S.F. Husain and M. Shariq focuses on modular and prefabricated housing systems under PMAY. The research emphasizes that factory-based modular construction can reduce construction time and improve efficiency through off-site manufacturing and on-site assembly, making it suitable for affordable housing projects.

New Construction Systems for PMAY by Dr. Shailesh Kr. Agrawal, J. K. Prasad, S. K. Gupta, and Dalip Kumar examines alternative construction technologies for PMAY housing projects. It highlights that precast concrete systems, steel structures, and prefabricated technologies can improve construction efficiency and support faster delivery of affordable housing compared to conventional RCC construction methods.

Promoting Precast Concrete for Affordable Housing in India by Arifullah P. Sherfudeen, Nitish Kumar, Raghavan N., Radhakrishna G. Pillai, and Satyanarayana N. Kalidindi highlights the importance of precast concrete technology in addressing affordable housing shortages in India. The research indicates that industrialized and prefabricated construction systems can reduce project duration and improve construction quality in large-scale housing developments.

8. METHODS

The methodology of the study outlines the overall approach adopted to examine the feasibility of Industrialized Building Systems (IBS) within the Beneficiary-Led Construction (BLC) component under PMAY-U in Bhubaneswar. The methodology includes the formulation of aim and objectives, collection of primary and secondary data and analysis of the collected information to evaluate the feasibility of IBS in BLC housing.

8.1 AIM & OBJECTIVES

The study aims *To examine the feasibility of adopting Industrialized Building Systems (IBS) within the Beneficiary-Led Construction (BLC) component under PMAY-U in Bhubaneswar*. The objectives of the study focus on - (1) To explore the role of Industrialized Building Systems (IBS) in the context of affordable housing and understand their applicability within the PMAY-U BLC framework in Bhubaneswar; (2) To assess the existing PMAY-U BLC construction process in Bhubaneswar with respect to cost, construction duration and quality to identify the potential scope for IBS-based approaches; (3) To evaluate the technical, financial and social feasibility of adopting IBS for BLC housing in the study area.

8.2 PRIMARY & SECONDARY DATA COLLECTION

The study involved the collection of both primary and secondary data to analyze the existing BLC housing scenario and evaluate the feasibility of IBS integration. The collected data focused on construction practices, beneficiary perception, housing quality, implementation challenges, and awareness regarding IBS technologies.

Primary data was collected through field surveys, questionnaires, stakeholder interactions, and direct observations conducted in selected BLC housing areas of Bhubaneswar. The survey focused on construction timelines, costs, housing quality, awareness about IBS, acceptance levels, and implementation challenges faced by beneficiaries and stakeholders.

Secondary data was collected from government reports, PMAY-U guidelines, research papers, journals, planning documents, census data, and published literature related to affordable housing and Industrialized Building Systems. Various case studies and previous research findings were also reviewed to understand the role of IBS in housing development.

8.3 DATA ANALYSIS

The collected data was analyzed using qualitative, quantitative and feasibility-based approaches to evaluate the existing BLC construction process and the applicability of Industrialized Building Systems (IBS) in affordable housing. Various graphs and charts were prepared to examine parameters such as construction time, cost efficiency, labour dependency, construction quality, scalability, and beneficiary perception. The analysis was carried out to understand the overall feasibility and suitability of IBS-based approaches, particularly Precast Concrete Construction (PCC), in the context of PMAY-U BLC housing in Bhubaneswar.

9. RESULTS

9.1 CURRENT SCENARIO OF BLC

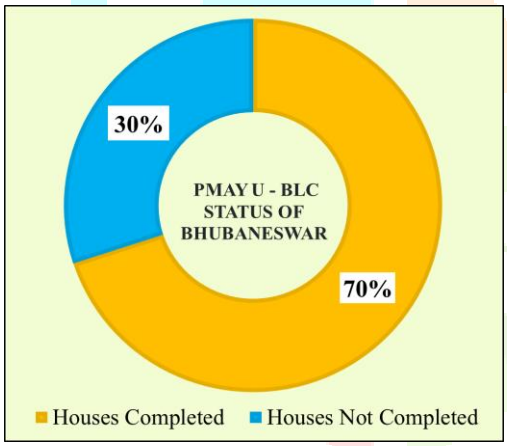

Fig. 2: PMAY - BLC Status of Bhubaneswar

Table 1: PMAY U - BLC Progress across Different Zones of Bhubaneswar

ZONES	WARDS	TOTAL NUMBER OF DWELLING UNITS
North Zone	2, 3, 4, 5, 9, 10, 14, 18, 19	471
South East Zone	31, 32, 34, 43, 44, 45, 53. 54 55, 59, 60, 67	218
South West Zone	22, 23, 37, 38, 39, 49, 50, 51, 52, 62, 63, 64, 65, 66	203
Total BLC Dwelling Units Completed		**892**
Total BLC Dwelling Units Sanctioned		**1266**

The current status and implementation of the PMAY-U BLC component in Bhubaneswar shows, Out of a total of 1266 sanctioned dwelling units, 892 houses have been completed, indicating around 70% completion. The North Zone has the highest concentration of completed dwelling units with 471 units, followed by the South East Zone (218 units) and South West Zone (203 units). This indicates that BLC implementation has been more prominent in the northern part of the city.

9.2 CONSTRUCTION STAGES OF BLC

Fig. 3: Foundation Stage

Fig. 4: Plinth Stage

Fig. 5: Wall Construction Stage

Fig. 6: Roofing Stage

Fig. 7: Finishing Stage

Fig. 8: Completion Stage

The conventional construction stages involves - *Foundation* to ensure structural stability, *Plinth* to establish the base for flooring, *Wall Construction* defines the layout of the house, *Roofing* completes the main structural frame and provides protection to the house, *Finishing* improves the appearance and livability of the house, and *Completion* where the house is fully constructed and ready for occupancy with all services. Each stage faces issues such as delays, poor workmanship, lack of technical supervision, quality inconsistencies, rework, and cost overruns. Therefore, the integration of IBS is proposed as a solution to improve speed, accuracy, and construction quality.

9.3 TECHNICAL ANALYSIS OF PRECAST CONCRETE CONSTRUCTION (PCC)

PCC is a construction method which involves off-site production of standardized concrete components such as beams, columns, slabs and wall panels using reusable moulds, controlled curing conditions and strict quality assurance processes. These prefabricated elements are then assembled on-site using mechanical handling equipment and connected through wet or dry joints to ensure structural continuity, stability, and load transfer. It is the most suitable IBS method for BLC housing in Bhubaneswar as it can effectively address major challenges of delay, cost escalation, labour dependency and quality inconsistency associated with conventional construction, while enabling faster delivery, improved quality and scalable implementation as well as suitability for Odisha's cyclone-prone conditions with structural strength for 100 years. Its adaptability to local conditions, higher acceptance among beneficiaries and the presence of local precast facilities enhance its feasibility, practicality and adoption.

The PCC process progresses through 5 stages where it begins with *Design and Planning*, where components are standardized and plans are prepared. This is followed by *Mould Preparation and Casting*, where concrete elements are produced in reusable moulds. The components then undergo *Curing, Quality Checking and Storage* to ensure strength and durability. Next, they are transported to the site, while *Site Preparation and Foundation* work are carried out simultaneously. Finally, *Erection, Connections and Finishing* are completed by assembling precast components on-site to form the finished building.

The key advantages include faster construction, timely delivery, improved durability, reduced labour dependency, better precision, cost control, reduced rework, and scalability. The various components of PCC are - *Precast Slabs*: Factory-made floor and roof panels that reduce weight, improve strength and speed up construction. *Precast Columns & Beams*: Structural elements that support the building by transferring loads safely to the foundation. *Precast Wall Panels*: Ready-made walls that provide better finish and reduce plastering work. *Precast Staircases*: Pre-manufactured stair units that are quickly installed.

Fig. 10: PCC Construction Components – Precast Slabs, Precast Columns & Beams. Precast Wall Panels, Precast Staircases

Precast concrete connections ensure structural stability and load transfer. They include *horizontal connections* for load distribution across horizontal surfaces and *vertical connections* for transferring loads downward. Structural joints include *beam-to-column, slab-to-beam,* and *wall panel connections*, which integrate different components into a unified system. The Assembly process starts with site preparation and foundation readiness, followed by transport and positioning of precast components. Columns are erected first and stabilized, after which beams and slabs are installed to form the structural frame. Then, wall panels are fixed, creating the building enclosure. Then, connections are completed, temporary supports are removed and finishing works with services installation are done resulting in a complete structure.

9.4 SOCIO - ECONOMIC ANALYSIS OF BENEFICIARY PERCEPTION ON IBS IN BLC HOUSING

A sample size of 45 beneficiaries was determined using the Yamane sample size formula based on completed BLC houses across different zones of the city.

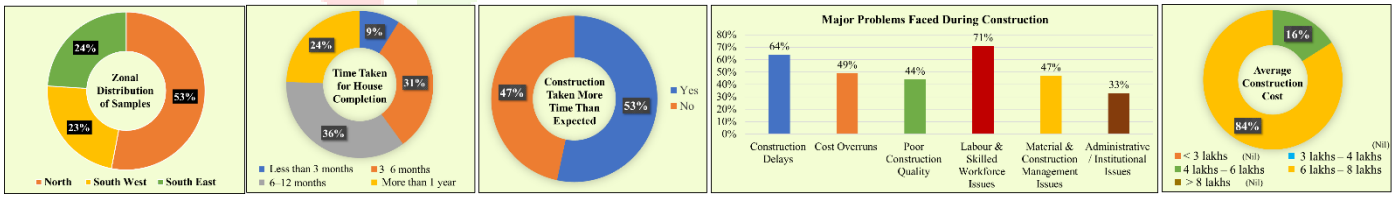

Fig. 11: Statistical Overview of Construction Duration, Costs and Major Issues in BLC Housing Projects

The analysis indicates that conventional BLC construction in Bhubaneswar faces significant inefficiencies, with around 60% of houses taking more than 6 months to complete and over half of the beneficiaries experiencing delays beyond expectations. Labour-related issues (71%) and construction delays (64%) emerge as the most critical challenges, followed by cost overruns (49%) and quality concerns (44%). Most houses (84%) fall within the ₹6–8 lakh range, suggesting noticeable cost escalation. These interconnected issues- labour dependency, delays, rising costs, and inconsistent quality highlight systemic weaknesses in the BLC process and emphasize the need for a more efficient and standardized construction approach.

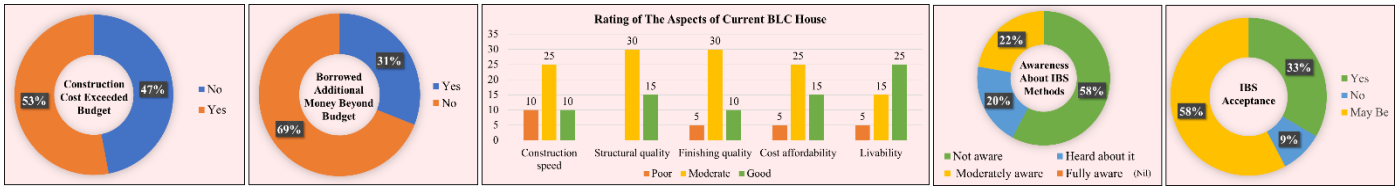

Fig. 12: Statistical Overview of Beneficiary Perception towards IBS and Existing BLC Housing Conditions

The analysis indicates significant financial stress among beneficiaries, with 53% reporting cost overruns and 31% needing to borrow additional money during construction. Most aspects of current BLC houses are rated as "moderate" particularly construction speed, structural quality, finishing, and affordability while only a smaller share rate them as "good," indicating average performance rather than high satisfaction. Awareness of IBS remains low, with 58% not aware, yet acceptance potential is strong, as 58% are willing to consider (maybe) and 33% are ready to adopt. This indicates that despite moderate satisfaction with existing housing, there is clear financial pressure and a strong openness towards improved construction methods like IBS.

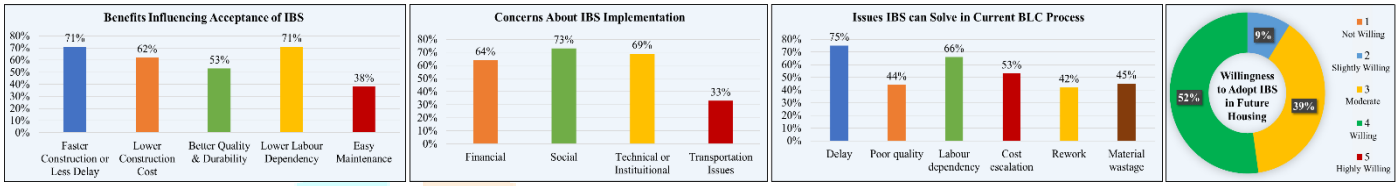

Fig. 13: Statistical Overview of IBS Benefits, Concerns and Future Adoption Willingness in BLC Housing

The analysis indicates that beneficiaries strongly recognize the advantages of IBS, with 71% highlighting faster construction and reduced labour dependency as key benefits, followed by 62% for lower cost and 53% for improved quality and durability. Major concerns relate to social awareness and trust (73%) and technical or institutional challenges (69%). Beneficiaries also perceive IBS as effective in addressing core BLC issues such as labour dependency (75%), construction delays (66%) and cost escalation (53%). Overall willingness to adopt IBS is positive, with 52% respondents are willing and 39% respondents are moderately willing, indicating strong potential for adoption if awareness and implementation support are improved.

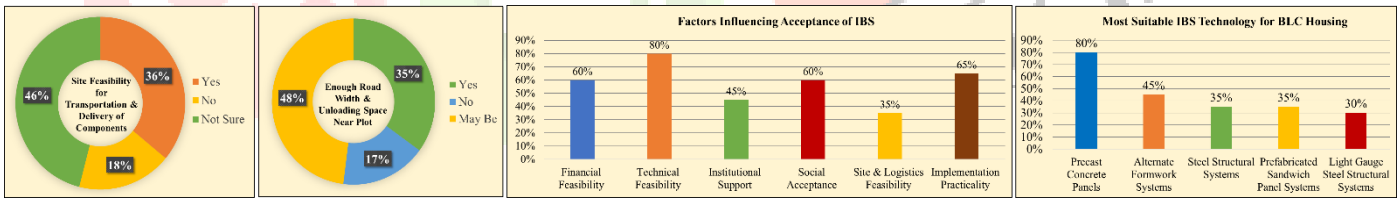

Fig. 14: Statistical Overview of Site Feasibility, Acceptance Factors and IBS Technology Selection

The analysis highlights that site and logistics feasibility presents a mixed scenario, with 46% respondents unsure, 36% considering it feasible while 48% indicate lack of adequate road width or unloading space, showing logistical constraints for IBS implementation. In terms of factors influencing adoption, technical feasibility (80%) emerges as the most critical, followed by implementation practicality (65%), financial feasibility and social acceptance (60% each). Regarding technology preference, Precast Concrete Construction is the most favored (80%), significantly higher than alternate formwork (45%), steel structural systems and sandwich panels (35% each), and light gauge steel systems (30%), clearly establishing PCC as the most suitable and preferred IBS technology for BLC housing in Bhubaneswar.

10. FINDINGS & CONCLUSION

The study highlights that the increasing demand for affordable housing in Bhubaneswar requires construction approaches that are faster, more efficient, and capable of maintaining quality within limited project timelines. Through the analysis of existing BLC housing practices under PMAY-U, it was observed that conventional construction methods often face challenges related to labour dependency, construction delays, rising material costs, and inconsistent workmanship. The study further identified that IBS particularly

Precast Concrete Construction, have significant potential to improve construction efficiency, reduce project duration, minimize material wastage, and enhance overall quality control in BLC housing. The findings also indicate that the use of IBS can support more systematic and scalable housing development while reducing dependence on on-site construction activities.

The study concludes that IBS adoption in BLC housing in Bhubaneswar is highly feasible from a technical and financial perspective, while social acceptance is promising but constrained by low awareness. Overall, the findings support the integration of IBS, particularly Precast Concrete Construction as a viable and efficient alternative to conventional BLC construction.

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