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AKSHAYA COLLEGE OF ENGINEERING AND TECHNOLOGY

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DEPARTMENT OF CIVIL ENGINEERING

TECHNICAL MAGAZINE

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Message from the Head of Department

The Department of Civil Engineering was started in 2010. It currently offers a Bachelor's degree in Civil Engineering with 30 seats and a Master's degree in Structural Engineering with 18 seats. The department has qualified faculty and staff with expertise in areas like Structures, Geotechnical Engineering, Construction Management, Environmental Engineering, and Transportation Engineering. Civil Engineering is important for the growth of all engineering fields. It teaches students how to plan, analyze, design, build, and maintain structures like buildings, roads, bridges, and dams.The department has modern and well-equipped laboratories, including the Advanced Structural Engineering Laboratory, Strength of Materials Laboratory, Hydraulic Engineering Laboratory, Survey Laboratory, Environmental Engineering Lab, Soil

Dr.R. Premsudha,
Professor & Head,
Department of Civil Engineering

Mechanics Laboratory, Concrete and Highway Engineering Laboratory, and the Computer Aided Building Drawing Laboratory.

Vision and Mission of the department

Vision of the Department

To produce quality Civil Engineers having domain knowledge embedded with design, analysis, and research capability, ethical and moral values, for the welfare of society and humanity.

Mission of the Department

DM 1: To produce knowledge based Civil Engineers by focusing theoretical and practical studies with field orientation.

DM 2: To engage the students in creating design solutions for real life problems associated with industry and society.

DM 3: To inculcate entrepreneurship culture along with professional ethics among Civil Engineering students and also promote the use of modern tools and techniques for sustainable economic growth.

Program Educational Objectives (PEOs)

PEO 1: Design Techniques: The graduates will be able to apply the concepts of basic geometrical construction, preparation of plans, design of structural elements, specification, and prepare estimates.

PEO 2: Construction Quality & Control: The graduates will be able to build the infrastructure required for the country and apply the tools for quality in construction, cost effective construction materials and methods.

PEO 3: Leadership: The graduates will be able to work as a member and leaders in a team, prepare and present reports, and employ project management tools for the evaluation and review of projects globally.

Program Specific Outcomes (PSOs)

PSO 1: Professional skills: Students shall have skills and knowledge to work on projects on urban and rural housing infrastructure, environment, and sustainability.

PSO 2: Competency: Students shall qualify at the state, national, and international level competitive examination for employment, higher studies, and research.

Program Outcomes (POs)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO 6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and Team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Message From Editorial Team

Welcome to an exciting edition of the technical magazine of the Department of Civil Engineering, where innovation, creativity, and technology converge. In this issue, we delve into a wide array of topics, from the latest advancements in construction materials and sustainability to cutting-edge developments in Construction techniques and practices. Our mission with this magazine is to create a platform where ideas can flourish, where students and faculty alike can showcase their work, share their knowledge, and contribute to the ever-evolving world of technology. We believe that through collaboration and the exchange of ideas, we can foster an environment that nurtures innovation and drives progress.

We would like to extend our heartfelt gratitude to all contributors who have taken the time to share their insights and expertise. Your work is the keystone of this publication, and it is your dedication that makes each edition of our Magazine a success.

As you explore the content within these pages, we encourage you to think beyond the boundaries, to question, to innovate, and to contribute to the vibrant tapestry of ideas that defines our institution.

Thank you for your continued support and enthusiasm. We hope you enjoy this issue as much as we have enjoyed putting it together.

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EXPERIMENTAL INVESTIGATION OF BUBBLE DECK SLAB

Abstract :

This project aims to explore the structural performance, sustainability benefits, and potential applications of bubble deck slabs, providing valuable insights for engineers, architects, and builders seeking to reduce the environmental impact of construction projects while maintaining structural integrity and performance. Highlights the industry's shift towards sustainability and efficiency. Introduces the innovative solution of bubble deck slabs. It Explains the benefits of bubble deck slabs, including reduced material usage and environmental footprint. It clearly states the investigation's objectives and potential impact.

Introduction:

In the construction industry is shifting towards sustainable and efficient building practices, driven by growing concerns about environmental impact, resource conservation, and cost-effectiveness. One innovative solution gaining attention is the bubble deck slab, a cutting-edge technology that integrates spherical voids within the slab to reduce material usage, weight, and environmental footprint. By minimizing the amount of concrete and reinforcement materials used, bubble deck slabs offer a promising approach to achieving more sustainable and efficient building designs.

Objectives:

Evaluate Structural Performance: Assess the load-carrying capacity, deflection, and failure modes of bubble deck slabs. Investigate Sustainability Benefits: Quantify the environmental benefits of bubble deck slabs, including reduced material usage and carbon footprint. Optimize Design Parameters: Determine the optimal size, shape, and distribution of voids in bubble deck slabs for maximum material reduction and structural performance. Compare Cost-Effectiveness: Evaluate the cost implications of using bubble deck slabs compared to traditional construction methods. Identify Design and Construction Guidelines: Develop guidelines for designing and constructing bubble deck slabs, including best practices and potential challenges to address.

Design Concept and Methodology

The Bubble Deck slab system is a bi axial, voided slab construction method that reduces the amount of concrete used in flat slabs by introducing spherical plastic voids in areas where concrete does not contribute to structural performance. This concept is rooted in the principle that concrete in the central zone of a slab between the compression and tension zones acts primarily as dead weight and can be replaced without compromising strength. The design aims to optimize material usage, reduce dead load, and enable longer spans while maintaining structural integrity and serviceability.

Design Concept

The primary objective of this project is to design and analyze a reinforced concrete slab using the Bubble Deck technique for a given set of conditions—such as span, imposed loads, and support configuration and compare its performance with a conventional solid slab. The system introduces HDPE hollow spheres (voids) uniformly across the slab, sandwiched between two layers of Fe500 steel reinforcement. These voids eliminate unnecessary concrete in the neutral axis, resulting in a lighter and more efficient structural element.

The concept also integrates:

Reduced dead load (up to 30–35%)

Lower material consumption (concrete and steel)

Improved seismic performance due to mass reduction

Flat slab soffit, eliminating the need for beams and increasing floor height clearance

The design follows the principles outlined in IS 456:2000 for reinforced concrete design and references relevant sections of Euro code 2 for voided slab systems, as Indian codes do not yet provide detailed guidance on Bubble Deck design.

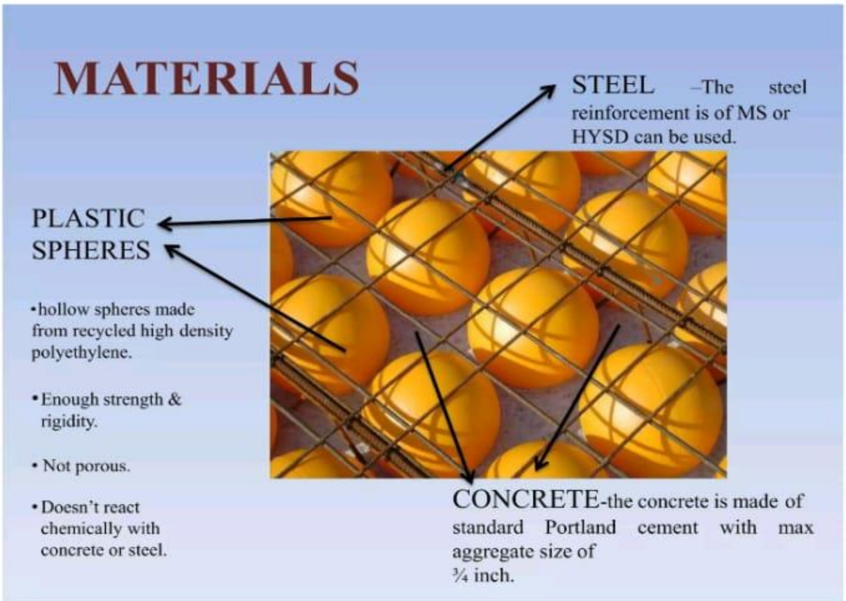

Fig 1: Components of Bubble Deck Concrete

Materials

Concrete:

Concrete plays a vital role in the performance and integrity of the Bubble Deck slab system. In this innovative construction method, concrete is used not only to provide compressive strength but also to integrate with a network of recycled plastic spheres and steel reinforcement to form a lightweight, bi axial structural slab. The concrete must be carefully selected and mixed to ensure that it flows adequately around the void former without leaving air pockets or voids. Typically, a high-performance concrete mix such as self-compacting concrete (SCC) or a high-slump pump able mix is used to guarantee full encapsulation of the plastic balls and reinforcement mesh. The most commonly specified concrete grades for Bubble Deck slabs range from C30/37 to C40/50 (or M35 to M45 in IS standards), depending on structural requirements. To enhance work ability, super plasticize are often added, while supplementary cementitious materials like fly ash, GGBS (Ground Granulated Blast Furnace Slag), or silica fume may be incorporated to improve long-term durability, reduce shrinkage, and lower the environmental impact.

Proper concrete placement is critical, as it must be poured gently and allowed to flow under and around the voids without displacing them. Because the slab includes large plastic spheres, a smaller aggregate size-usually 12 to 16 mm-is preferred to ensure smooth flow and reduce the risk of obstruction. In addition to structural performance, the concrete must also meet fire resistance, vibration, and acoustic criteria. Curing is equally important, with a recommended minimum of 7 days of moist curing or the application of curing compounds to prevent premature drying. When properly designed and executed, the concrete in the Bubble Deck system contributes to a high-strength, lightweight slab that offers significant material savings and supports sustainable construction goals.

Steel Reinforcement:

Steel reinforcement plays a critical role in the structural performance of the Bubble Deck slab system, working in tandem with concrete to create a strong, durable, and flexible floor solution. While concrete provides compressive strength, it is relatively weak in tension. This is where steel reinforcement becomes essential, as it provides the necessary tensile strength to resist bending moments, shear forces, and cracking. In the Bubble Deck system, reinforcement is typically arranged in two orthogonal layers-top and bottom-forming a bi axial reinforcement grid that enables the slab to span in both directions without the need for beams. The steel used is generally high-yield deformed bars or welded mesh, often conforming to grades such as **B500B**, which provides a yield strength of 500MPa and ensures excellent bond characteristics with concrete.

The presence of recycled plastic spheres in the slab's central zone does not compromise the steel's effectiveness, as the voids are carefully positioned within the neutral axis, where stresses are minimal. The steel reinforcement surrounds these spheres in the upper and lower zones of the slab, maintaining the structural continuity required for load transfer and overall slab integrity. In precast or semi-precast Bubble Deck panels, the bottom layer of reinforcement is typically installed at the factory, while the top layer is placed on-site before the in-situ concrete pour. This method ensures that the slab performs as a single, monolithic unit once completed. The reinforcement is also critical for controlling shrinkage and thermal cracking during and after curing. Proper detailing, anchorage, and cover depth must be ensured to maintain corrosion resistance and long-term durability. Overall, steel reinforcement in the Bubble Deck system not only strengthens the slab but also enhances its flexibility, safety, and suitability for a wide range of architectural and structural applications.

Recycled High-Density Polyethylene (HDPE) or Polyethylene (PP):

The Bubble Deck slab system incorporates plastic void former made from **recycled high-density polyethylene (HDPE)** or **polypropylene (PP),** both of which are durable, lightweight thermoplastics widely used in construction and manufacturing. These materials are selected not only for their **mechanical and chemical stability** but also for their **sustainability**—as they are often sourced from post-consumer or industrial plastic waste. Their use in Bubble Deck void former contributes directly to reducing environmental impact by repurpose plastic that would otherwise contribute to landfill or ocean pollution. Both HDPE and PP are known for being **non-toxic, non-corrosive, and highly resistant to moisture, chemicals, and biological degradation**, making them ideal for long-term use embedded in concrete slabs.

Formed into hollow **spherical or ellipsoidal shapes**, these recycled plastic void former are positioned in the neutral axis of the slab, where they displace non-structural concrete and reduce the slab's self-weight by up to 35%. This not only improves material efficiency and structural performance but also reduces the amount of concrete and steel required—thereby decreasing **embodied carbon emissions**. The use of HDPE or PP ensures the voids maintain their shape during production, transportation, and concrete pouring, withstanding the weight and pressure of surrounding materials without deformation or failure.

In addition to their structural role, the recycled plastic void former aligns with global sustainability standards, supporting LEED certification and green building practices. Their integration into precast or semi-precast panels enhances construction efficiency while maintaining high safety and performance standards. By using recycled HDPE or PP, the Bubble Deck system successfully combines **innovation, sustainability, and structural efficiency,** offering an environmentally responsible alternative to traditional concrete slabs without compromising load-bearing capacity or durability.

Working:

The Bubble Deck slab works by eliminating unnecessary concrete from the slab's neutral axis—the area that contributes little to structural strength—by inserting hollow plastic spheres. These spheres are embedded between the top and bottom steel reinforcement meshes. This configuration reduces the slab's self-weight while maintaining its load-bearing capacity. When concrete is poured, it binds the upper and lower mesh layers, forming a two-way reinforced slab. The bubbles act as void former, and the slab behaves like a solid flat plate in bending and shear, effectively transferring loads to the supporting columns or walls. This innovative system allows for longer spans, fewer columns, and thinner slabs, contributing to structural efficiency and material savings.

The core principle behind the working of a Bubble Deck slab lies in optimizing the structural behaviour of concrete slabs by removing non-functional concrete from the centre of the slab. By strategically placing lightweight, hollow plastic balls between two layers of reinforcement, the system maintains the slab's bending stiffness while significantly reducing its dead weight. The top and bottom concrete layers handle compressive and tensile stresses respectively, while the plastic bubbles reduce mass where stresses are minimal. This enables the slab to perform efficiently under load, allowing for wider spans, reduced structural height, and lower foundation loads.

During construction, the Bubble Deck system integrates prefabricated panels containing hollow plastic balls and steel reinforcement, which are placed on-site and joined by in-situ concrete. Once the concrete hardens, the slab acts as a monolithic structure with reduced weight but full structural capacity. The voids created by the bubbles do not compromise strength, as they are placed in zones where concrete is not structurally essential. This method not only lightens the slab but also improves seismic performance and reduces overall construction time due to the prefabricated nature of the system.

Advantages:

The Bubble Deck slab system offers numerous advantages that make it a highly efficient and sustainable alternative to conventional solid reinforced concrete slabs. One of the most significant benefits is the substantial reduction in self-weight. By replacing the non-structural concrete in the slab's neutral zone with hollow plastic spheres made from recycled materials, the system can reduce the overall weight of the slab by up to 35%. This lower self-weight directly leads to reduced loads on columns, foundations, and other structural elements, which not only saves materials but also reduces construction costs and foundation depth. Additionally, the lighter structural system enhances the seismic performance of buildings, making it a more suitable option for earthquake-prone areas. Another key advantage of the Bubble Deck system is its ability to span longer distances without intermediate supports or beams. Typical spans of 12 to 18 meters are achievable, which provides architects and engineers with greater design flexibility. The ability to eliminate beams results in flat slab construction, which simplifies the integration of mechanical, electrical, and plumbing (MEP) systems, reduces floor-to-floor heights, and increases the net usable floor area.

In terms of construction efficiency, the Bubble Deck system contributes significantly to faster project timelines. Many projects employ prefabricated or semi-prefabricated panels that arrive on-site with voids and bottom reinforcement already in place, which drastically reduces the amount of on-site labour and time required for installation. As a result, fewer workers are needed on site, and the potential for human error is minimized. The system also requires significantly less form work compared to traditional slab systems, leading to further savings in both time and resources. This simplified construction process can be particularly beneficial for large-scale or fast-track projects where speed and efficiency are critical. From an economic perspective, the reduction in concrete and steel quantities results in direct material cost savings, and the overall decrease in building weight can reduce the cost of the entire structural frame and substructure. Additionally, with fewer internal columns required due to the long spans, architectural layouts become more flexible and adaptable, increasing the usable space for tenants and potentially raising the building's commercial value.

Sustainability is another core advantage of the Bubble Deck slab. The system contributes to greener construction practices by reducing the volume of concrete used—consequently lowering carbon dioxide emissions associated with cement production. Moreover, the use of recycled plastic for the void former promotes the reuse of waste materials, aligning with global efforts toward circular construction. Environmentally conscious builders and developers can benefit from these aspects in achieving green building certifications such as

LEED or BREEAM. From an architectural standpoint, the absence of beams creates a clean, flat ceiling finish that enhances interior aesthetics and allows for more consistent lighting and air distribution. Finally, the Bubble Deck system maintains comparable performance to traditional slabs in terms of fire resistance and sound insulation, making it a practical, durable, and safe option for a wide range of building types. Overall, the Bubble Deck slab system offers a blend of structural innovation, environmental responsibility, economic efficiency, and architectural flexibility that makes it a compelling choice for modern construction.

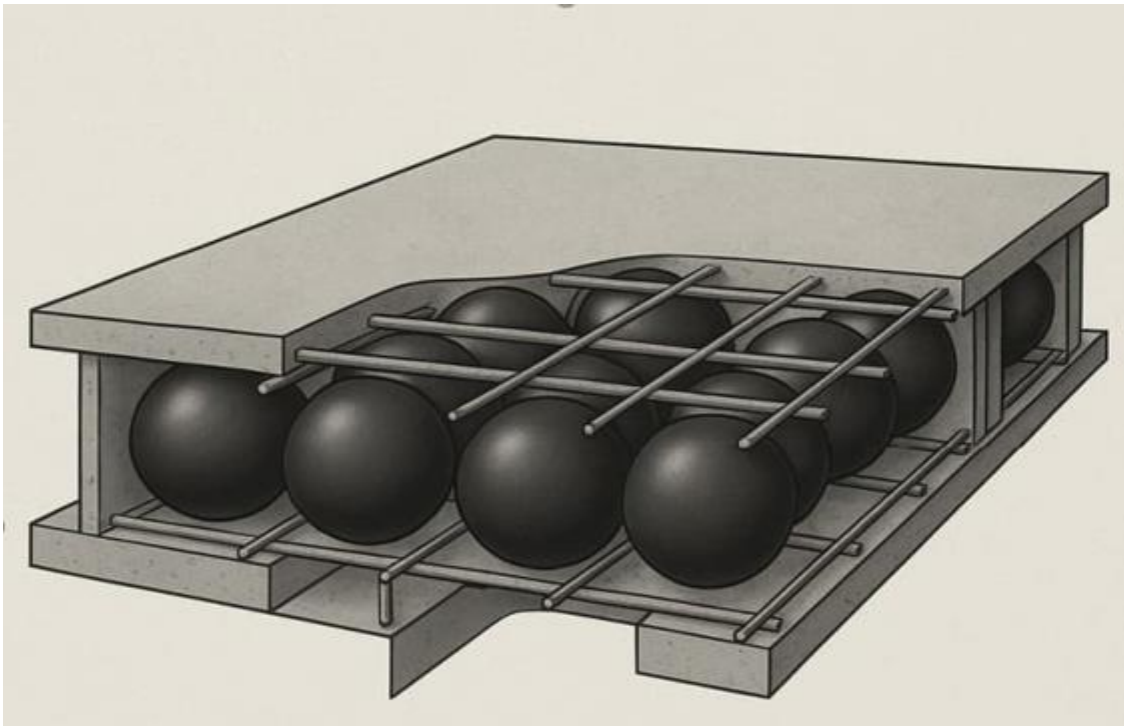

Fig 2: Process Method Diagram

Cost Estimation:

An accurate cost analysis is critical for evaluating the feasibility of adopting Bubble Deck technology in construction projects. The following section provides a comparative cost estimate between conventional solid slabs and Bubble Deck slabs, taking into account material savings, labour efficiency, and prefabrication costs.

COMPONENT	CONVENTIONAL SLAB (INR/m²)	BUBBLE DECK SLAB (INR/ m²)
Concrete	900	630
Steel Reinforcement	750	600
Plastic Void Former	0	200
Form work and Label	650	500
Prefabrication/Transport	0	300
Total Estimated Cost	2300	2230

Table shows that Comparison of CC and BDC

In projects where Bubble Deck slabs replace beam-and-slab systems, there is also the added benefit of eliminating drop beams, reducing architectural complexity and allowing for faster service integration. While the cost of void former and prefabrication is an additional consideration, these are often offset by the reduced use of concrete, form work, and labor. Additionally, faster construction cycles can lead to earlier project delivery, resulting in economic benefits for commercial developers.

Moreover, lightweight structures require less reinforcement in foundations and columns, contributing to significant cumulative savings across the building. The ease of installation and reduced manpower requirement further lower the overall cost, especially on sites with space or labor constraints. Hence, from both a direct cost and life-cycle perspective, the Bubble Deck system proves to be a cost-efficient alternative.

Fig 3 : Preparation of Mould

Fig 4: Preparing of Concrete and Casting

Fig 5 : Removal of Mould

Fig 6: Curing the Specimen

Fig 7 : Testing the concrete

Conclusion:

The study has comprehensively explored the Bubble Deck slab system, a modern, sustainable, and structurally efficient alternative to conventional solid concrete slabs. The core innovation of this system lies in its use of recycled plastic spheres to eliminate non-structural concrete within the slab's neutral axis, resulting in reduced weight, material savings, and enhanced sustainability. This voided slab concept addresses both environmental and structural challenges by optimizing material usage and minimizing the embodied energy of buildings.

Through analytical modeling, comparative analysis, and a review of existing literature and practical implementations, the research has established that Bubble Deck slabs can achieve weight reductions of up to 30–35%, without compromising the slab's structural integrity. These weight reductions translate into several cascading benefits: decreased foundation loads, fewer structural supports, and greater design flexibility. The slab’s bi axial behavior ensures that it distributes loads uniformly in two directions, making it ideal for wide-span floor systems in commercial, institutional, and high-rise buildings.

In terms of structural performance, the Bubble Deck system matches or exceeds traditional slabs in critical parameters such as flexural capacity, punching shear resistance, and serviceability. Finite element simulations and empirical data confirm that with appropriate reinforcement detailing and void placement, the system remains within permissible deflection and stress limits defined by IS 456:2000 and Euro code 2 standards. Moreover, the use of prefabricated panels and modular assembly techniques significantly reduces construction timelines, site labor, and form work requirements.

Sustainability is a central advantage of the Bubble Deck system. By incorporating recycled plastic spheres and reducing the need for cement—a major contributor to CO_2 emissions—the system supports environmentally responsible construction. Additionally, the flat soffit configuration simplifies the integration of MEP services, improving efficiency in interior space planning and reducing the floor-to-floor height of buildings.

Despite its merits, the Bubble Deck system also presents some challenges. These include a higher initial investment due to specialized materials and prefabrication, a steeper learning curve for contractors unfamiliar with the technology, and limitations in smaller or irregular floor plans. Moreover, the lack of detailed provisions in many national building codes can hinder widespread adoption. Nevertheless, the long-term advantages in cost savings, construction speed, and environmental impact make a compelling case for broader use.

Future Work:

The successful application of the Bubble Deck system opens the door to several avenues for future research and improvement. This study recommends the following areas for further investigation:

Long-Term Durability Studies: While current studies confirm the structural viability of Bubble Deck slabs under standard loading conditions, there is a need for long-term durability assessments. These should include the system's behavior under environmental stressors such as corrosion, freeze-thaw cycles, chemical attack, and varying humidity. Life-cycle analysis (LCA) data can further inform sustainable design strategies.

Seismic Performance Evaluation: Given the reduced mass of Bubble Deck slabs, it is hypothesized that they would perform favorably in seismic zones. However, extensive testing under cyclic and dynamic loads is essential to validate this assumption. Real-world seismic simulations, shake table experiments, and numerical modeling could be conducted to develop region-specific design guidelines.

Fire and Acoustic Insulation: The use of plastic voids could potentially affect the fire resistance and soundproofing capabilities of the slab. Research should aim to quantify fire ratings, flame spread, and heat transfer characteristics of slabs containing HDPE or PP voids. Likewise, acoustic performance studies can guide their use in residential and educational buildings.

Integration into Building Codes: Widespread adoption of the Bubble Deck system requires formal recognition within national and international design codes. Future work should focus on collaborating with regulatory bodies to develop standards and guidelines specific to voided slab systems.

Hybrid Systems and Innovations: Integrating the Bubble Deck approach with other sustainable technologies (such as radiant floor heating, integrated solar panels, or thermal mass systems) can multiply the benefits. Research into hybrid applications and multi-functional slab systems would align with the goals of net-zero construction.

Comparative Case Studies: A broader database of real-world projects utilizing Bubble Deck slabs, including post-occupancy evaluations and cost-benefit analyses, will help benchmark performance and strengthen the case for its adoption in diverse building types.

In conclusion, the Bubble Deck system represents a progressive shift in the design and construction of concrete floor systems. Its holistic advantages—structural, economic, and environmental—make it an exemplary model for modern construction. Continued research and technological innovation will only enhance its potential, positioning it as a standard solution for future sustainable building projects.

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