Review on Bubble Deck Slabs Technology & Their Real-Life Implementation

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I.ABSTRACT:

A fashion known as "bubble deck slab" reduces structural dead weight significantly by basically removing all concrete from the center of a floor slab that is not serving any structural purpose. In the middle of the slab, ineffective concrete is replaced with high density polyethylene hollow spheres, which reduce dead weight and boost floor effectiveness. By creating the cavities, the slab becomes 30 to 50 percent lighter than conventional reinforced slabs and reducing the loads on the foundation, walls and columns and of course, the entire structure. Reduced energy use for manufacture, transportation, and prosecution as well as lower emigrations of exhaust gases from these processes, particularly CO2, are the benefits. The end of this paper is to talk over about various types of constructing bubble deck slab technology like filigree elements, reinforcement modules and finished planks. Materials use for bubble deck slabs, produce and transporting out process and eventually argue about real- life operations of bubble deck technology for numerous advantageous aspects of bubble deck slab technology.

Keywords- Bubble Deck Slab, High Density Polyethylene (HDPE), Hollow Sphere, CO2 Emigrations, Filigree Element, Reinforcement Modules, Finished Planks.

II.INTRODUCTION:

The construction industries frequently searching innovative approaches and materials to enhance structural efficiency, reduce material consumption and lower costs without compromising safety and functionality. For similar advancement the concept of bubble deck slab provides alternative way to the conventional reinforced concrete slab. [1]

A conventional slab generally used in maximum structures, is a solid, reinforced concrete component designed to bear loads and transfer this load to the supporting beams and columns. Such conventional slabs constructing system material leads to additional contribution and increasing dead load with improved costs. [2]

The biaxial hollow core Bubble Deck Slab was created in Denmark by Jorgen Bruenig, a Danish engineer in the year of 1990s. This method substantially reduces structural dead weight by eliminating nearly all of the concrete that serves no structural purpose from the center of a floor slab. Bubble deck slab is grounded on a new patented fashion which involves the direct way of linking air and steel. Void forms in the middle of a flat slab by means of plastic spheres exclude up to 35 percent of a slab's self- weight, removing constraints of high dead loads and short spans. This system provides adjustable layout which easily adaptable for irregular and curving plan configuration. [3]

This technology is sustainable and eco-friendly. The business or proprietor can avoid 278 tons of CO2 emigrations from the use of concrete and save 1745 gigajoules of energy consumed in the production and transportation of concrete for every 5000 m2 bubble deck slab. also, carbon in the slab can be reduced by up to 40 percent by using lower concrete. Using smaller materials will also reduce carbon emigrations from accoutrements and transportation. Furthermore, the HDPE bubbles that are consumed can be recycled or saved for use in other projects. By adopting bubble deck technology in construction we will eliminates total construction costs up to three percent. The ratio of diameter of plastic spheres to the thickness of floor is similar that 35 percent saving is attained on the material or concrete consumption for the floor of the same thickness. [4]

III.TYPES OF BUBBLE DECK:

All of the Bubble Deck systems come in three forms- filigree elements, reinforcement modules, and finished planks. They're depicted in Figure 1. For all types of Bubble Deck, the maximum element size for transportation reasons is 3m.[5]

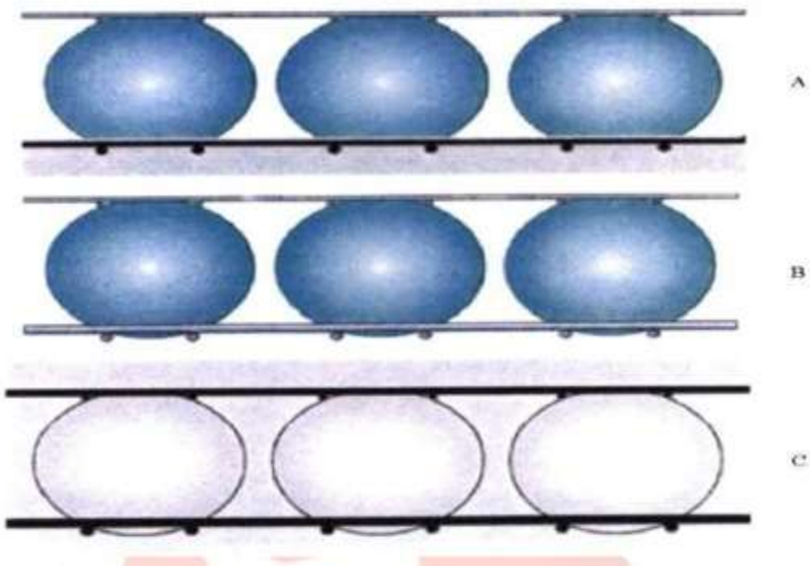

FIGURE 1: TYPES OF BUBBLE DECK SLAB

TYPE A – FILIGREE ELEMENTS:

A Type A Bubble Deck has both built and unbuilt region. A 60 mm thick concrete subcaste is precast and brought to the job location without the bubbles or steel reinforcements attached. The bubbles are furthermore held in place by a honeycomb of interlinked steel mesh and temporary stands on top of the precast layer. further steel can be added depending on the design's reinforcement needs. Normal concreting ways are used to reach the full depth of the slab and it's finished as necessitated. This type of Bubble Deck works best for new construction programs where the innovator can choose where the bubbles will go and how the steel mesh is laid out.

TYPE B – REINFORCEMENT MODULES:

Bubble Deck Type B is a reinforcement module made of pre-assembled steel mesh and plastic bubbles, frequently known as" bubble fabric". The elements are carried to the point, put on traditional formwork, reinforced, and eventually concreted using traditional fashions. Bubble Deck modules can be piled for storehouse, making them ideal for assembling regions with limited space.

TYPE C – FINISHED PLANKS:

Bubble Deck Type C is a shop- fabricated module that includes plastic spheres, reinforcement mesh, and concrete. It's delivered on- position in the form of a plank and has a one- way spanning design that requires support beams or load- bearing walls. This type of Bubble Deck is ideal for shorter spans and limited construction schedules.

IV.MATERIALS FOR CASTING BUBBLE DECK SLAB: [6]

1. **Cement**- Type: Ordinary Portland Cement (OPC) 53 Grade, as per IS: 12269.

FIGURE 2: CEMENT

2. **Fine Aggregate (Sand)**- Grading Zone: Should be from Zone II & III (as per IS: 383).

FIGURE 3: FINE AGGREGATE

3. **Coarse Aggregate**- Aggregate > 4.75mm (as per IS: 383).

FIGURE 4: COARSE AGGREGATE

4. **Steel (Reinforcement)** As per Design.

FIGURE 5: STEEL BARS

5. **HDPE Balls**- Material: High Density Polyethylene (HDPE).

FIGURE 6: HDPE BALL

6. **Water**- Drinkable water.

V.PRODUCTION AND IMPLEMENTATION PROCESS [9]

Stage 1: The process begins with the fabrication of plastic spheres, typically made from recycled materials. These spheres are formed using specific molds and are produced in various diameters, depending on design requirements. Once ready, they are stored for later use (see Fig. 7). [7]

FIGURE 7: PLASTIC SPHERE IN STORAGE

Stage 2: A bubble-lattice structure is created by securing the plastic spheres between two layers of steel reinforcement. This is done by welding the upper and lower reinforcement layers together, effectively locking the spheres in position. This step ensures that the spheres remain fixed during further processing (see Fig. 8). [8]

FIGURE 8: WELDING THE REINFORCEMENT

Stage 3: Diagonal bars are used to connect the top and bottom reinforcement grids. These short girders help stabilize the position of the spheres, maintaining their placement within the lattice (see Fig. 9).

FIGURE 9: DIAGONAL GIRDERS STRUCTURE

Stage 4: A thin concrete layer is prepared on casting tables or platforms to form the base of the filigree slab. This base layer supports the bubble-lattice when it's positioned for the next stage (see Fig. 10).

FIGURE 10: PREPRATION OF BOTTOM LAYER CONCRETE

Stage 5: The assembled bubble-lattice, which includes the spheres and the welded reinforcements, is placed onto the prepared concrete layer. For filigree systems, this step happens in the factory. In the case of modular reinforcements, the entire lattice is transported to the construction site for placement.

Stage 6: The initial concrete layer is compacted to eliminate air pockets and enhance strength. This is typically achieved using platform or table vibrators.

Stage 7: Once the filigree elements are fully assembled, they undergo finishing procedures. These completed segments are then moved to storage.

Stage 8: Finished Bubble Deck elements are loaded onto trucks and transported to the construction site.

Stage 9: At the site, tower cranes are used to lift and install the filigree slabs. Skilled labour is required to ensure proper alignment, secure connections, and a seamless fit between elements to maintain the structure's stability.

Stage 10: Final concreting is done at the construction site. Needle vibrators ensure deep compaction, while surface vibrators are used to achieve a smooth, aesthetically pleasing finish.

VI.REAL LIFE IMPLEMENTATION OF BDS [11]

1) Millennium Tower

Rotterdam, Netherlands The Millennium Tower stands as a pioneering example of Bubble Deck technology application. Located in Rotterdam, it was the first project to incorporate bubble-filled slabs as part of its structural system. During the early planning stages, engineers opted for the Bubble Deck solution, which significantly sped up construction allowing 10 floors to be completed within just 4 days. This method reduced the number of support columns by 50% and eliminated around 500 truck deliveries due to the minimized use of concrete. The absence of traditional beams also allowed for the addition of two extra floors within the same vertical space. The tower, which reaches a height of 130.8 meters and comprises 35 floors, was completed in 2000. It was designed collaboratively by WZMH Architects and AGS Architecten and remains one of the tallest structures in the Netherlands.[10]

FIGURE 11: MILLENNIUM TOWER

2) MPCC Building

Beckenham, Perth, Australia The Multi-Purpose Community Centre (MPCC) in Beckenham was the first public building in Australia to use the Bubble Deck system. Constructed by PACT Construction and completed in October 2016, the project required a total built-up area of 2,300 square meters. The structure incorporated 132 semi-precast Bubble Deck panels for suspended slab construction. The use of voided two-way slabs significantly reduced the building's foundation load and allowed greater flexibility in the footing design, minimizing potential settlement issues. As a result, the project saved approximately 250 cubic meters of concrete and reduced the overall mass by about 20% compared to conventional slab systems. The MPCC earned a six-star green building certification and received accolades for excellence in sustainable construction.

FIGURE 12: MPCC BUILDING

3) Office Building

West Leederville, Australia Georgiou Group, a national leader in construction and property development, incorporated the Bubble Deck system into a mixed-use development located near Loftus Road and Railway Parade in West Leederville. The development includes three underground parking levels and a combination of commercial and office spaces. Architectural firm Meyer Shircore designed the structure with long two-way slab spans measuring up to 8.5 by 8 meters. Structural engineers specified BD280 slabs to provide a cost-effective and efficient solution for the building's varied usage. Approximately 13,400 square meters of semi-precast Bubble Deck panels were produced by certified manufacturer Austral Precast. The development features two basement parking levels, a ground-level café and office space, and four additional levels of commercial offices, with an estimated 5,500 square meters of BDS incorporated into the overall construction.

FIGURE 13: OFFICE BUILDING

4) BDCC Multi-Storey Car Park

Malaysia A significant application of the Bubble Deck system can be seen in a multi-storey car park developed by BDCC in Malaysia. This project utilized Bubble Deck's voided slab technology, which incorporates hollow plastic balls within concrete slabs. This innovation effectively reduces the amount of solid concrete needed in the slab's core where it contributes the least to structural strength leading to multiple practical advantages. The lighter slabs significantly decreased the structural weight, improving load distribution and reducing stress on the building's foundation. This weight reduction allowed for longer spans between columns, which meant fewer internal supports were required. As a result, the design provided more open and flexible parking spaces enhancing both functionality and vehicle maneuverability.

VII.CONCLUSIONS:

- The use of Bubble Deck technology significantly lowers the structural dead load, which in turn allows for smaller and more cost-effective foundations.
- Substantial reductions in concrete consumption are achieved—1 kilogram of recycled plastic can replace up to 100 kilograms of concrete. This not only minimizes environmental impact but also results in construction cost savings ranging between 2.5% and 10%.
- Bubble Deck slabs offer enhanced acoustic performance, contributing to better sound insulation within the structure.
- The system also improves fire safety by enabling more fire-resistant slab configurations compared to traditional concrete slabs.
- Construction timelines are shortened due to the ability to precast the slabs off-site. Since the slabs require less concrete, they also allow for faster on-site casting and handling.
- In terms of sustainable building practices, Bubble Deck contributes to green construction. As reported by the manufacturer, each kilogram of recycled plastic used reduces the need for 100 kilograms of concrete, cutting embodied carbon in slabs by up to 40%. Additionally, the HDPE plastic spheres are reusable and recyclable, further supporting eco-friendly initiatives.
- On a project scale, for every 5,000 square meters of Bubble Deck flooring:

  i. Approximately 1,000 square meters of on-site concrete is saved.
  ii. Around 166 concrete truck deliveries are avoided.
  iii. Carbon dioxide emissions are reduced by an estimated 278 tons.
  iv. The foundation load is decreased by approximately 1,798 tons, potentially eliminating the need for 19 support piles. (Data from Bubble Deck UK)

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