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Structural Behaviour of Biaxial Hollow Slab and its Application in Construction Industry

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ABSTRACT:

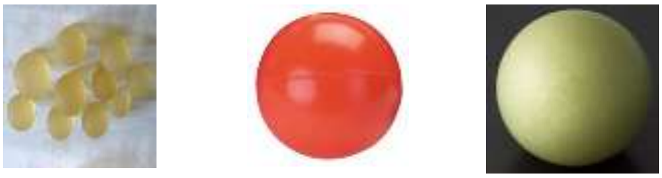
The paper's goal is to compare Biaxial hollow slab with Conventional Slab, based on a few investigations. There must be adjustments made in the building industry as infrastructure develops because using the same approach repeatedly could have unfavorable effects. The scarcity of labor and supplies is the primary effect. Additionally, money is the increasing need for constructing a building, and in some places, the level of machinery, equipment, and technology that is needed by society is not being met. To meet these needs, bubble deck slabs have been discovered to be one of the most economical and materially efficient ways to replace traditional slabs. Removing almost all of the concrete in the middle of the floor slab reduces the dead weight of the slab. The use of high-density polyethylene balls lowers the slab's self-weight and boosts its efficiency. By replacing concrete partially by HDPE balls, the slab becomes between thirty and fifty percent lighter, which lessens the strain on the foundation, walls, and columns. It also helps to lower overall expenses and CO2 emissions

Keywords: Recycling, traditional slab, HDPE balls, CO_2 emission, Biaxial Hollow slab, Polyethylene.

INTRODUCTION:

Jorgen Braunig invented the first voided slab, popularly referred to as the "bubble deck slab". The biaxial voided slab is a two-directional slab with HDPE balls integrated in the middle that serves no structural purpose. The slab has almost entirely been cleared of concrete. Nonetheless, as defiance is correlated with concrete depth, the voided hollow slab floor's shear strength is noticeably lower than that of a solid slab. Design reduction factors have been suggested as a means of compensating for these variances in strength. Germany, Denmark, the Netherlands, and the United Kingdom have all certified this system. The primary function of the plastic sphere is to lower the deck's deadload in contrast to a normal slab of the same thickness, without jeopardizing the deck's bending strength or deflection behaviour. Since less concrete is utilized, the slab weighs less even though it is cast with all the characteristics of a solid slab. Even if the structure is later refurbished or demolished, the spheres could still be recycled. In addition to adding insulating value, foam can be added to the hollow spheres' dead air gap to boost energy efficiency and improve sound and fire resistance. The arrangement of spheres of various sizes within a grid of reinforcement determines the geometry of the Bubble Deck slab and helps the deck reach a predetermined overall thickness. A bubble deck slab yields floors 20% faster than those with beams and reduces the formwork, resulting in a 12% decline in building activity costs and a 32% reduction in concrete usage. Voided deck slabs come in 3 varieties: filigree pieces, completed plank, and reinforcing modulus. A filigree element is a combination of produced and unproduced parts. A voided slab that blends precast manufacturing and in-situ building is called a filigree component. A 60 mm thick sheet of precast concrete is brought into site, reinforcement and the balls are placed according to their spacing conditions. For new building projects where the designer has total control over the positioning of the bubbles and the configuration of the steel mesh, this kind of bubble deck is ideal. Pre-assembled steel mesh and plastic bubbles make up the bubble deck type B reinforcing module. These parts are sent to the job site, where they are placed on conventional formwork, connected to any extra reinforcement, and concrete is poured using conventional techniques. This type has the benefit of being appropriate for small construction sites since the parts can be stacked on the site prior to installation. The shop-fabricated bubble deck type C module comes with plastic spheres, reinforcement mesh, and concrete. Once the module is built to the required depth, it is delivered on-site as a plank. The shorter span sections are primarily where type-C is recommended. There are 3 components make up a bubble deck slab: hollow bubbles, reinforcement bars, and concrete. Typically, 20 mm of mix aggregate and regular Portland cement is used to make concrete. Typically, concrete is made up of aggregates, water, and regular Portland cement. Self-compacting concrete is usually used for pre-casting slabs or filling joints because it fills in the spaces between each ball and prevents voids from occurring in the concrete. The reinforcement is made up of two layers- one at the top and one at the bottom that can be joined by welding or tying. Most of the reinforcing material must be Fe 500 grade. As seen in **Error! Reference source not found.**, several kinds of balls are utilized in the construction of bubble deck slabs. Usually, high-density polypropylene or polyethylene is used to make the hollow balls. These slabs are just as strong and stiff as regular slabs in sufficient amounts. The diameter of HDPE balls ranges from 180 mm to 450 mm. This determines the thickness of the slab, which ranges from 230 to 600 mm, and requires that the space between HDPE balls be larger than 1/9 of the diameter of the balls.

Plastic balls Steel Balls Polyurethane Balls



Hollow Plastic Balls Polyethylene balls Phenolic Balls

Figure.1

LITERATURE REVIEW:

[1] According to ***Reshma Mathew and Binu.P. (2016),*** who used a glass fiber reinforced polymer strengthening system in their investigation, the concentrated load capacity of the biaxial slab is a significant issue because of its small weight due to the hollow balls. When comparing strengthened slabs to regular bubble deck slabs, the punching capacity of the former was higher. The use of glass fiber reinforced polymer to stiffen the bubble deck slab resulted in a 25% improvement in load capacity. When compared to an un-reinforced bubble deck slab, the strengthened bubble deck did not exhibit as much deflection. Cement manufacture accounts for 8% of the world's carbon dioxide emissions. 800 kg of CO2 is released for every ton of cement. The CO2 emissions from one m3 of concrete are around 300 kg.

[2] According to ***Vinay Singh Chandrakar and Nagma Fatma (2018)*** noted that the continuous bubble deck slab lowers the amount of concrete, which in turn lowers the slab weight. In addition, the load on the continuous bubble deck slab has increased by up to 23% as compared to the standard slab. However, the way the balls are arranged affects the slab's ability to support loads; an alternate configuration of bubbles increases the slab's ability to support loads by 11% and 6% over a conventional slab, but less than a continuous bubble deck. The elasticity property of a bubble deck slab was simultaneously enhanced; for example, compared to a conventional slab, a bubble deck slab deflects 6% less. The quantity of bubbles within the slab also influences the elasticity property. The key component of a bubble deck slab is weight reduction. Using bubbles in the slab reduces costs and time because the weight of the slab and the amount of concrete it contains indirectly impact the beam and walls, allowing building foundations to be built for lesser dead loads. It is determined that, as compared to conventional slabs, load, deflection, and weight characteristics produce better results for bubble deck slabs.

[3] According to ***M. Ranjitham and N. V. Manjunath (2018)*** conducted an observational and experimental study comparing the structural behavior of a standard slab with a Bubble Deck Slab. When compared to solid slabs, the bubble deck technology reduces weight by 25% and is sustainable and environmentally friendly because it eliminates the need to produce cement, which lowers world CO2 emissions. Approximately twenty-five percent less concrete is needed for a continuous bubble deck than for a regular slab. In addition, bubble deck slab has enhanced the slab's elasticity property. Using bubbles in the slab reduces costs and time by reducing the weight of the slab and the indirect load that the concrete volume has on the walls and beams. This allows building foundations to be planned for reduced dead loads. It is concluded that Load, deflection and weight parameters gives better result for bubble deck slab as compared to conventional slab. Both in numerical and experimental results bubble deck slab shows a high load bearing capacity.

[4] According to ***Ahmed Ismael Adil and Farzad Hejazi (2019)***, bubble deck slabs are superior in terms of stress criterion and can support a greater weight than traditional concrete slabs. Because the bubble deck slab is 35 percent lighter than a traditional slab, less cement will be used, which will result in lower CO2 emissions and additional cost savings. Despite having less concrete in the bubble deck slab than in a regular slab. The material design of the bubble deck slab allowed for a 50% reduction in dead weight, a 50% speed increase in building time, and an overall cost reduction. Eventually, bubble deck slab is more useful and efficient than a solid conventional slab in office floor. The voided biaxial slab's shear strength is 0.6 times more than that of the traditional slab of the same thickness. On the other hand, vertical reinforcement can be used to achieve necessary resistance. Extruded hollow slabs are subjected to a fire test, with a resistance of fire duration of 25 minutes. Our information indicates that the crashes are moulded in the lower border of the hollow, and sometimes they fall below, based on this test and other trials reported in literature from actual fires.

[5] According to ***T.V.S. Vara Lakshmi, Dr. Y.S.R.A.N.U. (2023)*** observed and compared the compressive strength at 7, 28, 90, 180, and 360 days of the normal conventional concrete cube (CCC), bubble deck concrete cube (BDCC), and bubble deck fly ash concrete cube (BDFACC) using 30 mm, 60 mm, and 90 mm polypropylene hollow balls in the bubble deck concrete cubes (BDCC) and bubble deck fly ash concrete cubes (BDFACC), as well as for the percentage of weight reduction. It has been noted that the concrete's compressive strength drops by 0 to 0.3 percent as the percentage of weight reduction rises. Additionally, the compressive strengths of the Bubble Deck concrete cubes (BDCC), Bubble Deck Fly concrete cubes (BDFACC), and Conventional concrete cubes (CCC), Conventional Fly concrete cubes (CFACC), were almost equal.

[6] According to ***R Omar, N A Muhamad Khairu Saleh (2014)*** observed when exposed to a uniformly distributed area load, the reinforced concrete solid slab (SS) with two-way spanning exhibits a resistance to bending deformation that is 62.39 percent greater than that of the reinforced bubble deck (BD) slab. In comparison to the reinforced concrete solid slab (SS) that spans in the same direction, the reinforced bubble deck slab (BD) has a stiffness ratio of 0.396. Compared to the reinforced concrete solid slab (SS) that spans in the same direction, the two-way spanning reinforced bubble deck slab (BD) has a lower shear resistance because shear cracks propagate more frequently on the BD.

[7] According to ***Tina Lai (2009)***, the office slab test set supported earlier research findings, demonstrating that the Bubble Deck slab outperformed a conventional solid concrete, biaxial slab. Because HDPE spheres reduced dead weight compared to concrete, the maximum stresses and internal forces in the voided deck were up to 40% lower than in the solid one. The bubbles' reduced stiffness resulted in a little increase in deflection of the Bubble Deck slab of 10%, but this was not enough to offset the slab's overall reduction in stress. These findings show that, given a uniform, dominant gravity, this kind of biaxial deck will produce better long-term results and a more durable floor slab. Nevertheless, the office slab set performed better than the bridge deck test set. Though the models were made with varied layouts and lower size, they shared the same essential parameters. In every category, the Bubble Deck response exceeded the solid slab's by more than 60%. A few variables that could contribute to this poor performance include the system's size and the deck's continuity.

[8] According to ***Dyg Siti Quraisyah and K Kartini (2020)***, there are three types of bubble deck slabs: filigree elements, reinforcement modulus, and finished planks. These techniques are effective for casting the slab and can reduce its self-weight by approximately 30 to 50 percent when compared to conventional concrete slabs. The amount of concrete used has decreased since 1 kg of recycled plastic can replace 100 kg of concrete, preventing the need to produce cement and lowering CO2 emissions worldwide.

[9] According to ***Ahmed A. Al-Ansari and Majid M. Kharnoob (2023),*** the bubble deck slab may be precisely replicated using the ABAQUS Sequential Thermo-mechanical coupling model. The weight of the bubbled slabs with a bubble diameter to slab thickness ratio (D/H) of 0.80 can be reduced by 27% when compared to a typical solid slab. Compared to the standard solid slab, bubbled slabs with D/H ratios of 0.80 can support 85% of the maximum load. As the loading strength reduced after burning the model for two hours at 600°C more than after burning it for one hour at 800°C, the firing duration has a comparatively greater effect on the loading resistance than the temperature rise for a shorter amount of time. Following an extended duration of fire exposure, the flexural capacity was significantly diminished. In a long, fierce fire, the ball would melt and eventually scorch with little discernible impact. Because the air bubbles are encapsulated within the concrete slab, bubble deck slabs provide between 17 and 39 percent higher thermal resistance than an equal solid slab of the same depth even though they are not meant to provide thermal insulation.

[10] According to ***Tomasz Gajewski and Natalia Staszak (2023)*** noticed the best designs for the bubble deck slab when it was subjected to a uniformly distributed load, considering the least amount of concrete needed and staying within the Eurocode standard's serviceability limit state. Furthermore, the bubble deck slab module that is, its length/width and height as well as the geometry of the ellipsoidal bubble void that is, its height and horizontal diameter were determined by applying the sequential quadratic programming local search algorithm to the minimization problem with linear constraints. According to the study, optimization allowed for the adoption of bubble deck slab designs that conformed with serviceability limits and ensured the lowest feasible concrete mass. Compared to the bubble deck's original design, the concrete saved 23% of its weight. It was demonstrated that the homogenization method employed in this work is very appealing since it avoids using the computationally costly finite element method to solve complicated structural issues. Rather than requiring extensive computations for a single design instance, which would take the same amount of time, an ideal bubble deck design might be achieved computationally in a matter of hours.

CONCLUSION:

A review of the bubble deck slab literature has been conducted. It has been noted that compared to a traditional concrete slab, the self-weight of a bubble deck slab can be lowered by roughly 30 to 50%. Concrete use is decreased because 1 kg of recycled plastic can replace 100 kg of concrete, preventing the need to produce cement and lowering CO2 emissions worldwide. In conclusion, bubble deck slabs provide several advantages over traditional concrete slabs, including increased structural performance, lower material and cost costs, increased efficiency, and quicker building times. Therefore, it is determined that this technology is sustainable and green for the environment.

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