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Bubble Deck

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Abstract: This paper proposes an approach for creating biaxial slabs using bubble deck. This approach avoids the limitations in hollow core slabs, lack of structural integrity, inflexibility and lack of architectural possibilities which produces the ways to reduce the weight of the building. It is used to decrease the amount of concrete used in a building, greatly strengthen the overall frame and distribute the weight of concrete that is actually used. The recycled plastic is used to make bubbles. These recycled plastic balls can be recovered during the demolition of building which helps to meet the goal of sustainable construction.
Keyword: solid slab, biaxial slab, plastic spheres, reinforcement, concrete, etc.

I. INTRODUCTION

Bubble Deck consists of hollow, high density polyethylene or polypropylene spheres, sandwiched between two structural steel mesh grids formed by welding together thereby creating a natural cell structure, acting like a solid slab. This system is based upon the patented integration technique which is the direct way of linking air and steel. It is a two way hollow deck in which plastic balls serves the purpose of eliminating concrete that has no carrying effect. The plastic balls responsible for this whole scenario are made up of recycled plastic and it can be entirely recyclable in the event of a building's demolition.

The bubble deck slabs has low weight, simplicity, symmetry and uniform extent which reduce the impact effect, uniform and continues distribution, monolithic and ductile structure. It serves 30-50% of self weight compared to the corresponding solid slabs which has equal stiffness.

Bubble deck acts like a solid slab, which does not have the earlier problems with reduced resistances towards shear, local punching and fire. As a consequence of reduced load, it is possible to achieve larger spans than a solid span. Depending upon the design, spans of 20 to 40 times the deck height are possible, cantilevers can be made 10 times the deck height. By incorporating post tension cables, these spans can be further enhanced.

II. LITERATURE REVIEW

A. Purnachandra Saha

Bubble deck slab is a method of virtually eliminating all concrete from the middle of a floor slab, which is not performing any structural function, thereby dramatically reducing structural dead weight. High density polyethylene hollow spheres replace the in-effective concrete in the centre of the slab, thus decreasing the dead weight and increasing the efficiency of the floor. By introducing the gaps leads to a 30 To 50% lighter slab which reduces the loads on the columns, walls and foundations, and of course of the entire building. The advantages are less energy consumption - both in production, transport and carrying out, less emission - exhaust gases from production and transport, especially CO2 .The paper is discuss about various properties of Bubble deck slab based on the various studies done abroad. Moment, deflection and stress distributions are verified using Finite Element Method (FEM) in SAP2000.

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B. Tina Lai

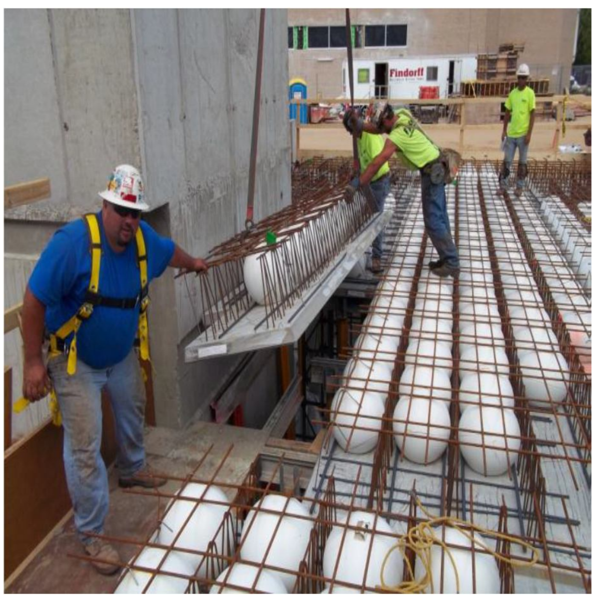
The BubbleDeck slab is a revolutionary biaxial concrete floor system developed in Europe. These biaxial slabs have many advantages over a conventional solid concrete slab: lower total cost, reduced material use, enhanced structural efficiency, decreased construction time, and is a green technology. Through tests, models and analysis from a variety of institutions, BubbleDeck was proven to be superior to the traditional solid concrete slab. The reduced dead load makes the long-term response more economical for the building while offsetting the slightly increased deflection of the slab. However, the shear and punching shear resistance of the BubbleDeck floor is significantly less than a solid deck since resistance is directly related to the depth of concrete. Design reduction factors have been suggested to compensate for these differences in strength. This system is certified in the Netherlands, the United Kingdom, Denmark and Germany.

In this investigation, after verifying the validity of the prior research through a finite element analysis of an office floor in SAP2000**,** the BubbleDeck slab was tested for a pedestrian bridge deck. Bridge design is dominated by the dead weight of the structure and by concentrated stresses from vehicular traffic. This new slab can solve both of these problems by reducing weight with the plastic spheres and by applying it to a pedestrian bridge to limit the high stresses. A set of bridge decks were modeled and analyzed in SAP2000 for this study.

III. METHODOLOGY

The actual construction of the bubble deck incorporates what is known as biaxial slab, meaning that two wire grids rest on a ball. Each of these grids can be placed between slabs of concrete, with numerous balls closely arranged in a approximate grid form and a thinner grid is welded on top to form a "cage". This cage is fixed into 3 inches of concrete to form a panel.

The bubbles are made by embodying high density polypropylene in the concrete and placed between the reinforcement meshes. The material that are not react chemically with the concrete or the reinforcement, it has no porosity, has enough rigidity and strength to take over loads as much as possible from the pouring of concrete.



The nominal diameter of bubble gaps may be 180,225,270,315 or 360mm. The minimum distance between gaps is 1/9 of the gaps diameter. The total height of the bubble deck slab elements is constant. Function of the diameter of bubbles that are used may be the total height of slab is 230,280,340,390 or 450mm. The weight of the bubble deck slabs are corresponds to the function of its dimensions.

In order to increase the shear strength capacity and bending moment in the areas with stress concentration it is possible that in these areas gaps are not provided. Span of the slab various between 12m to 17m and width may be 2.4m or 3m. The concrete used for the precast layer can be of common concrete or self leveling concrete. Minimum grade of concrete that is used for the construction of slabs are M20 or M25.

The bubble deck slab gaps elements can be delivered by three versions that are

Version A: Reinforcement modules in which the spheres are placed to produce the gaps and if the case, tubes for HVAC modules that are to be placed in formworks. The plates are cast in place.

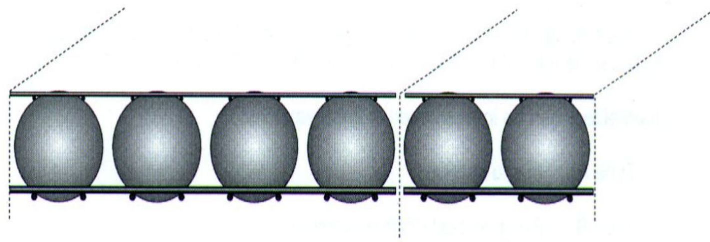


Fig.1: Version A – Reinforcement Modules.

Version B: Partial precast concrete elements. They have the bottom part made of precast concrete and the connections between elements and the over concreting are cast in place.

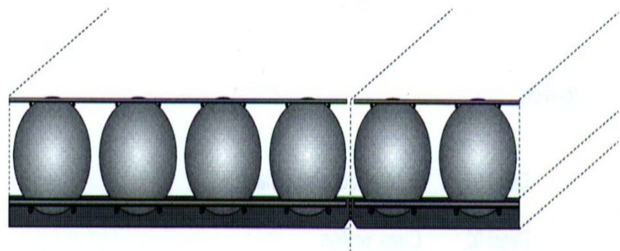


Fig.2: Version B – Filigree Elements.

Version C: Finished plank is a shop-fabricated module that includes the plastic spheres, reinforcement mesh and concrete in its finished form. The module is manufactured to the final depth in the form of a plank and is delivered on site. Unlike, version A and B, it is a one-way spanning design that requires the use of support beams or load bearing walls. This class of Bubble Deck is best for shorter spans and limited construction schedules.

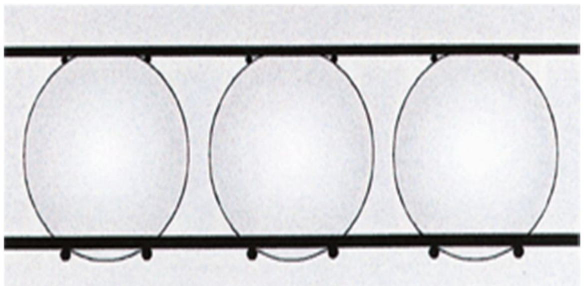


Fig.3: Version C - Finished Plank.

IV. MANUFACTURING

In order to achieve the reinforcement modulus for bubble deck slabs with gabs the following operations must take place.

A. Version

Making the reinforcement meshes.

Placing the pipelines, cables and element of electric fitting if in case.

Fixing small boxes or pieces of polypropylene on reinforcement meshes for making the portion of the walls or the columns and installation.

Placing of the polypropylene spheres between the meshes according to plan.

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Labeling of the reinforcement modules.

B. Version

Making of the reinforcement meshes.
Placing of the installation on the reinforcement meshes.
Fixing small boxes or pieces of polypropylene on reinforcement meshes or directly on the formwork for marking the portion of the walls or the columns and installation.
Placing of polypropylene spheres between the meshes according to planes.
Preparing the formwork. (cleaning, assembling, greasing)
Checking of the formwork and the reinforcement before pouring the concrete.
Preparing the concrete. Pouring the concrete. Foreseeing labels on elements.

C. Casting

Making cast in place slabs.
The formwork is made with supports calculated to hold the concrete's own weight and the loads that occur during pouring the concrete.
The reinforcement is placed according to the planes.
The position of the spheres is checked.
Placing te reinforcement at the connection with the columns or the wall areas.
The concrete M20/M25 is poured and vibrated.
The supports of the formwork and the formwork are removed when the slab is able to take over the own weight and the live loads.
Making the semi precast concrete slabs.
Each slab element needs to be temporary propped. The supporting elements need to be dimensioned so they can take over the weight of the semi precast elements, the reinforcement and the fresh concrete and also all the loads that occurs until the operation of concreting is finished.
The distance between the supporting beams should be not larger than 1800mm.
The temporary propping elements are kept in position until each part of the slab can support by itself.
The transversal reinforcement bars must be embedded in the adjacent slab elements.
In case that geometrical misshapes occur the adjustments of the element is possible by the means of a diamonded disk that creates the area that takes over the shear force. In these situations the integrity of the top part mesh is assured and also of the inclined reinforcement.
In this phase, the polypropylene pieces that mark the position of different elements are removed.
The upper reinforcement is directly led on the partially precast elements according to the reinforcement plans. Before pouring, the surface of the precast element is thoroughly cleaned. Immediately after pouring, the surface of the concrete is cleaned with under pressure water to remove the dust and to moisture the surface. Especially in times of high temperature the surfaces of the precast elements is kept wet to ensure the needed adherence.
Bubble deck with gaps reinforced on two directions, assures the mechanical strength and stability of construction by designing of the slab by calculating it for stresses given by dead and live loads. Reducing the weight of the construction loads is to reducing of the calculus seismic force. Bubble deck slabs with gaps are not toxic and environmental friendly, doesn't diffuse noxious substances and they are not radioactive and also reduce the quantity of carbon emitted.

V. ADVANTAGES

A. Supirior Statics

1) It helps to reduce the self weight or dead weight up to 50%
2) Larger spans (L/36) and larger overhangs (L/10) can be achieved.
3) No beams or ribs under the ceiling, pillars have no capital.
4) It needs only less number of columns.

B. Production and Carrying Out

1) Higher quality through automated production of prefabricated units.

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2) Less work in insitu.
3) Easier and more simple erection.
4) Less storage space.
5) Light and cheap lifting equipment.

C. Safety

1) Fireproof construction.
2) Earthquake- Safety will benefits significantly alone from the weight reduction.
3) Moisture- Condensation- safe construction.

D. Economic Saving

1) Savings in materials are substantial up to 50%
2) Subsequent works are simplified.
3) Buildings are more flexible.
4) Life span of buildings is longer.
5) Manual mounting of reinforcement meshes o the building site is avoided.

E. Environmental Improvement

Less energy consumption- both in production, transport and carrying out.
Less emission- exhaust gases from production and transport, especially co_{2S}.
No waste generation- 100% recycling.
Improvement of working conditions.
Reduced building time means less disturbances of surroundings.
Less emission of noise- in production, transport and assembly.
savings I materials- 1 kg of plastic replaces more than 100 kg of concrete.

F. Disadvantages

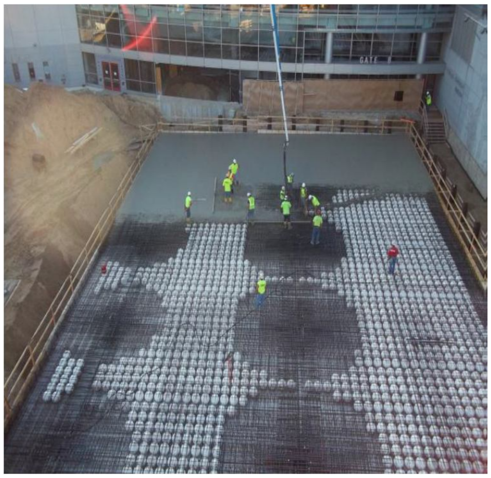
bours – If the construction worker substitute the bubbles in the place of concrete at the support region, it might prove disastrous.
Fitting of hollow plastic bodies in between lower steel mesh and upper steel mesh is always done in high position where a bubbledeck is casted, productivity of engineers and workers thus is being reduced much at the same time casting more time due to travel up and down or in case of casting concrete deck covered thousand square meter.
Costing much money for building formwork system.Requiring specialized welding machines and much time to weld spacers to connect lower and upper steel mesh. Moreover, structure with too much welding joints may change the properties of steel and reduce the durability of deck structure.Because spherical plastic bodies are hollow, these plastic bodies will float on to the surface as pouring concrete causing thrust and unstable structure. Costing much money for building of factories or workshop to manufacture deck elements.
Costing much money for transport these structures to construction sites. Besides, the thin concrete layer may be broken during transportation.
Because hollow concrete deck structure is heavy, It is essential to use huge capacity crane to lift these structure to the planned position and it is also very difficult for crane to access the desired position.
Costing more steel used to fabricate stiffeners which are used to move and lift deck structure.Due to the thin concrete layer is not at the same time casted with the concrete casted at construction sites, thus there is no integrity between them. This reduces technical efficiency and durability of bubble deck elements.
IS codal – The scope of our codal provisions aren't that wide and experimenting with new tech isn't something which is easy at that moment.

G. Bubble Filled Concrete Decks

Ariel View of the new Teaching and Learning Harvey building at Mudd College in Claremont, California.

Learning center is poised to be the first U.S. academic building to use the biaxial hollow slab product. Boora began to consider the bubble deck system because of the amount of weight it could eliminate from the buildings structure. The system allowed designers to keep the layout as open as possible, with high ceilings and clear spans of 35 feet between columns. The learning center's slim 13 inch floor slab leaves almost 14 feet of the 15 foot floor to floor height clear even with duct work and electrical elements installed. Installer recently finished placing the building's floor panels, containing more than 90,000 plastic balls, in only two days. In long term, the system will also allow the college to renovate more easily. Outlets or new openings can be made by core drilling into the slab rather than breaking through 13 inches of concrete.

H. Concrete top pour at the Labuan Arena in Madison, Wisconsin.



The LaBahn Arena is a four level hockey and swimming facility for the UW-Madison women's and men's hockey and swim teams. The project utilized the method of bubbles to build an underground walkway. With only edges forming at the perimeter, a decreased number of beams, along with coverage of typically 350 sq.ft. per panel, using bubble deck means that floors were constructed 20% faster than conventional construction methods.

I. Millennium Tower Rotterdam, Netherland.

It is also known as Weena tower. It was the first high rise building erected by using bubble deck(filigree elements). It was constructed during 1998-2000. It contains 34 stories and 140m height. It is choosen of its advantages, in cost, construction time and flexibility. Beams could be excluded resulting in two more stories than planned in the beginning for same height. The floors are build in 4 days instead of 8 days.

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J. Car park built with Bubble Deck in Frankfurt, Germany

It was constructed in 2001, to reduce the weight of slab and to get a wider span.

K. City Hall Centre, Glostrup, Denmark.

It contains floor area of 4000 sq.m. The city hall contains 3.3m cantilever from 280 deep slab with 7.5m spans between columns. In

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Denmark, for this building they awarded as “Building of year 2014”.

L. Dalhousie University, Nova Scotia, Canada.

The Mono Campbell building in Dalhousie University was constructed by using bubble deck. It is a commercial building of 101,303sq.ft. It is the third installation of bubble deck in North America. These bubble deck slab was consider by them for mainly reduction in the amount of materials and energy required for construction of the floor slab. These slab consists of 100% recycled plastic basket ball- sized spheres inserted within 11 inches deep of the slab. These slab take up room and save 30 % of the volume of concrete and also the energy and resources used to manufacture cement to make concrete is reduced considerable.

M. Le Coie Hotel, Jersey, United Kingdom.

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N. Fairlanes, Adelaide Tce, Perth.

VI. CONCLUSION

The construction floors in the building industry consists mainly of massive concrete floors, prefabricated filigree slab floors and hollow core slab floors. This situation has not changed for more than 20 years. But this innovative bubble deck slab construction technology is proven to be more efficient than a traditional biaxial concrete slab in an office floor system. As it saves the cost of building and reduces nearly 50% of self weight of the building. Thus, the studies on a variety of bridge layouts to determine the feasibility of bubble deck slab in a bridge construction also.

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