

STUDY AND MODEL MAKING OF SLAB USING BUBBLE DECK TECHNOLOGY

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Abstract- Concrete is a strong, durable material composed of cement, aggregate and water. Concrete has an ultimate load bearing capacity under compression, but the material is weak in tension. That is why steel bars are embedded in the concrete for the structure to carry tensile loads. The slab is very important structure member in building and slab is one of the largest member consuming concrete. The load acting on the slab is heavy or clear span between columns is more, the slab thickness is on increasing. It leads to consume more material such as concrete and steel, due to that the self-weight of slab is increase. To overcome these disadvantages various studies carried out and researchers suggest voided flat plate slab system to reduce the self-weight of slab. This technology is known as Bubble Deck technology. The objective of this paper is to convey the recent advancements in civil construction and implementing the new technique of using high density polyethylene hollow spheres in the construction field. It deals with the construction techniques and the innovation implemented considering the cost, efficiency and structural behavior of the concrete structure.

Keywords: HDPE Sphere, Plan, Design, Model Making, Cost Comparison.

1. INTRODUCTION

Concrete plays a major role in the construction field. The usage of concrete is high in slab construction. It leads to loss of concrete because the load transfers from the structure only on the column portion not throughout the slab. So that reduces the concrete in center of the slab by using recycled balls. High density polyethylene hollow spheres replace the in-effective concrete in the center of the slab, thus decreasing the dead weight and increasing the efficiency of the floor.

The method which replaces the concrete by recycled balls with less amount of concrete is known as "The Bubble Deck Technology". Bubble Deck, a unique light, biaxial concrete slab, is generally designed using the conventional design method. 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. The highly dense polyethylene hollow spheres put back the in-effective concrete in the center of the slab, thus decreasing the dead weight and increasing the efficiency of the floor.

This method deals especially in two directional reinforced composite concrete slabs with gaps. It ensures was

conceived to achieve saving of concrete and energy in buildings construction. It is a new patented technique and it is a direct of connecting air and steel. By using BubbleDeck method, the quantity of concrete and cement is reduced by 30 to 50% for the same built surface compared with the classical slabs, fact that gives an important reduced quantity of carbon emitted.

BubbleDeck slabs with gaps are interlocked so they don't produce risks during its working period. Bubbledeck has many advantages, beside it is reduced the material, the load, lower the cost and increasing the span length it is also a green technology. Since the punching shear capacity is one of the most important properties of flat slab, the influence of the cavities due to using the plastic balls on the punching behavior of self-compacted concrete was study in this paper.

2. MATERIALS DESCRIPTION

2.1 Recycled Balls

Generally, we used HDPE recycled balls because to reduce wastage of plastics instead of burning the plastics. The Bubble Deck slabs being entirely recyclable. Recycled balls can be recovered during the demolition of the building to meet the goal of sustainable construction. The recycled polyethylene hollow spheres are shown in fig 1.

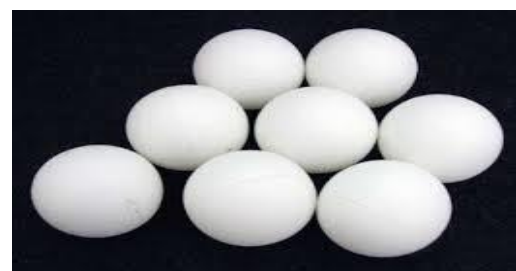


Fig-1: Recycled Polyethylene Hollow Spheres

Table 1- Properties of HDPE Ball

Specific Gravity	0.96
Water Absorption (Method A, 24hr)%	-
Tensile Strength at Yield, 100 psi	4.2
Elongated at Yield, %	900
Compressive Strength at Yield, 1000 psi	-
Rockwell Hardness (Method A)	R30-60
Maximum Service Temperature in °F	160
Natural Colour	Milky white
Colour Possibilities	Unlimited
Clarity	Translucent to opaque

2.2 Steel reinforcement:

High grade steel of Fe 550 or Fe 500 is generally used. The same grade of steel is used in both in top and bottom steel reinforcement. Reinforcement shall be accurately placed and secured in position in a manner that will prevent its displacement during the placement of concrete. Reinforcement provided in both transverse and longitudinal direction in the form of welded reinforcement mesh.

2.3 Diagonal girder:

The diagonal girders keep the bubbles fixed between the top and bottom reinforcement. It acts as a support to the ball. Girders that are applied as shear force reinforcement have to meet the following requirements:

- The centre-to-Centre-distance of the girder should be a maximum of twice the floor thickness.
- The centre-to-centre-distance of two down running or up running diagonals should be a maximum of $2/3$ of the floor thickness.
- Every pair of two diagonals, existing of one up running and one down running bar, should be welded with 2 welding points to both the lower and the upper longitudinal bar.
- The welding points with which the diagonals are attached to the lower and upper longitudinal bar should have a resistance per welding point of at least 25% of the flow strength of the diagonal.
- The distance between the edge of the floor support and the connection of the first diagonal from the floor support with the upper longitudinal bar of the girder should be maximal times the height of the girder. The diagonal girder with bottom reinforcement is shown in fig 1.3.



Fig- 2: Diagonal Girder

3. CONSTRUCTION METHODOLOGY

3.1. Bottom Reinforcement

The initial step is laying the bottom reinforcement for increase the tensile strength of the structure. It fetches the ball and aligns it in a straight line. Bottom reinforcements are two directionally welded reinforcement meshes. This figure 3 shows the bottom reinforcement



Fig-3: Bottom Reinforcement

3.2. Bottom Concrete

Concrete is provided at the bottom of the assembly line. It acts as a bonding material for ball because the ball attached with the concrete. The laying of bottom concrete shown in fig 4



Fig- 4: Laying of bottom Concrete

3.3 Location of Hollow Sphere

The hollow sphere is placed in between the reinforcement instead of concrete. Bottom reinforcement and diagonal girders keep the bubbles in position. Diagonal girders fixed between the top and bottom reinforcement. During the final positioning of the slab elements it is checked if the displaying of the spheres is according to the plans. Also, it is checked the reinforcement in the over concreting areas. The transversal reinforcement bars must be embedded in the adjacent slab elements. Partially precast made elements are designed and realized so that the building configuration is maintained. They are delivered with pieces of polystyrene included that mark the position of the walls or the columns. The location of sphere is shown in fig 5



Fig- 5: Location of Hollow Spheres

3.4 Provision of Top Reinforcement

After placing the balls, top reinforcement meshes are provided on the top of the sphere. It is positioning the ball and also act as a cover for the balls. The two meshes are connected after placing the spheres into places in order to forma rigid shell. In order to achieve the reinforcement modules for BubbleDeck slabs with gaps. The following operations must take place:

- Making the reinforcement meshes.
- Placing the pipelines, cables and element of electric fittings if the case
- Fixing small boxes or pieces of polystyrene on reinforcement meshes for marking the position of the walls or the columns and installations.
- Placing of the polystyrene spheres between the meshes according to plans. The fig 6 shows the provision of top reinforcement as below



Fig- 6: Provision of Top Reinforcement

3.4 Transportation

Semi manufactured slab transported through truck or crane and is shown below clearly.

3.4.1 Version A

Reinforcement modules in which the spheres are placed to produce the gaps and if the case, tubes for HVAC (electrical, heating, etc.), modules that are to be placed in formworks. The plates are cast in place.



Fig- 7: Transportation of Precast Bubble Deck Slab

3.4.2 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. The figure 7 and 8 shows that transportation of partially manufactured deck slabs.



Fig- 8: Transportation of Precast Bubble Deck Slab

3.5 Fixing of slab components

Fixing is the process of positioning and joining the semi manufactured slab. After fixing, concrete is provided over the slab. The following fig 9 shows fixing partially manufactured bubble deck slab.



Fig- 9: Fixing Partially Manufactured Bubble Deck Slab

3.6 Concreting

Concrete provided over the slab by pumping. Concrete is poured in between the ball gaps. Immediately after pouring, the surface of the concrete is cleaned with under pressure water to remove the dust and to moister the surface. Especially in times of high temperatures the surface of the precast element is kept wet to ensure the needed adherence and the connections of the partially prefabricated elements are not rigorously followed according to the design the concreting is adjusted with fluid mortar or with a thin layer of silicon pumped at the bottom part of the connection. In order to adjust the connections, one should never use expanded foams that may lead to reducing the thickness of the concrete layer and therefore to reducing the durability of the reinforcement and the fire resistance. Self-compacting concrete can be poured into forms, flow around congested areas of reinforcement and into tight sections, allow air to escape and resist segregation, without the standard consolidation efforts. The concreting process is shown in fig 10.



Fig-10: Slab Concreting

After concreting, vibration is provided for bottom and top concrete setting. Removing air content from the slab. Because of the little space between spheres, it is used a thin vibrator. The surface of the poured concrete is leveled with a metallic profile. The vibration process is shown in fig 11



Fig-11: Concrete Vibration

Finally, concrete surface finished with finishing tools. There is no further work required, the slab is complete unless requirement for exposed soffit. The surface finishing is shown in fig 12



Fig-12: Concrete Slab Surface Finishing

4. DRAWINGS

4.1 Plan of Bubble Deck Model

The fig 13 of plan view shows the arrangement of bottom reinforcement meshes with bubbles, column reinforcements and diagonal girder edge positioning

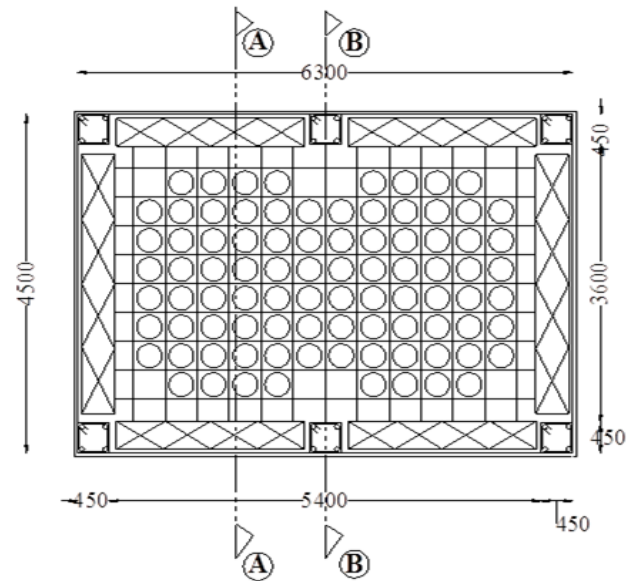


Fig-13: Plan View of Model

4.2 Cross Section of Bubble Deck Model

Fig 14 of section AA passes through the slab portion only. It represents the sectional view of the slab including diagonal girder and bubbles.

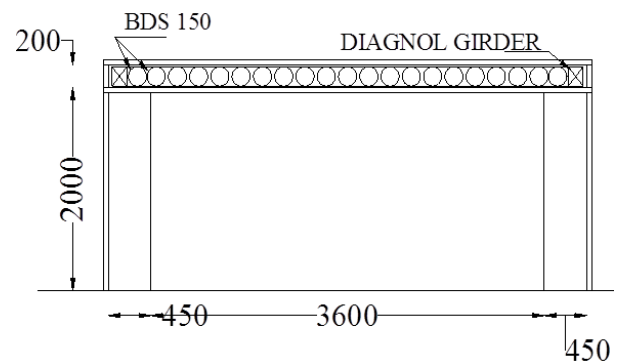


Fig-14: Section AA of Model

Fig 15 of section BB passes through the slab and column portion. It represents the sectional view of slab including column reinforcement details

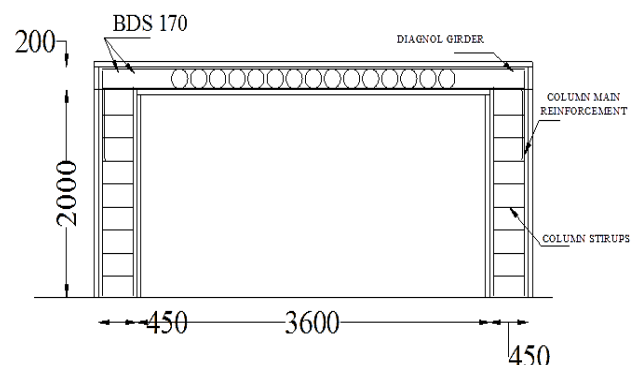


Fig-15: Section BB of Model

5. MODEL MAKING

The initial step is making column and slabs using acrylic sheets with 3mm thickness. The dimensions of column and slab are shown in Table 2.

Table 2-Model Dimensions

Member	Design Dimension (mm)	Scale	Model Dimension (mm)
Slab	Lx =4500 LY =6300	1:15	Lx=300 Ly=420 t=20
Column	Size=450*450 L=2000	1:15	Size=30*30 L=200

The model is done by using scaled dimensions as shown above and bottom reinforcement also shown in fig 16



Fig-16: Slab Model Bottom Reinforcement

The column reinforcements are provided in the structure and is shown in the fig 17



Fig-17: Column Reinforcement

The recycled balls are placed on the top of the bottom reinforcement with clear cover and is shown in fig 18



Fig-18: Arrangements of Recycled HDPE Hollow Sphere

The placing of top reinforcement on the structure and is shown in fig 19



Fig-19: Provision of Top Reinforcement Meshes

Fig 20 shows the model of recycled high-density polyethylene hollow sphere bubble deck slab



Fig-20: Bubble Deck Model

6. COST COMPARISONS

6.1 Bubble Deck Slab

Size of model slab = $6.3 \times 4.5 \times 0.3 = 8.505 \text{ m}^3$
 Amount of concrete replaced by bubbles is $(\frac{\pi \times 4^3 \times 0.270^3}{24 \times 250}) = 2.6 \text{ m}^3$
 Amount of concrete in bubble deck slab is $8.505 - 2.6 = 5.905 \text{ m}^3 \dots (1)$

6.2 Convectional slab

Beam in x-direction is $3(4.5 \times 0.3 \times 0.450) = 2.430\text{m}^3$
 Beam in y-direction is $4(2.7 \times 0.3 \times 0.45) = 1.944\text{m}^3$
 Slab portion is $2(3.9 \times 2.7 \times 0.18) = 3.7908\text{m}^3$
 Amount of concrete in convectional slab is $2.340 + 1.944 + 3.7908 = 8.0748\text{m}^3 \dots (2)$

6.3 Comparison

Concrete saving is calculated by comparing the equation = (2)-(1)

Quantity of concrete saved in model slab is $8.0748 - 5.90 = 2.1698\text{m}^3$ % of concrete replaced = $(2.1698/8.0748) \times 100 = 26.9\% \approx 27\%$

% of concrete replaced = 27%

Table 3- Comparison Between Bubble deck and Conventional Concrete Slab

Convectional slab	Bubble deck slab
<ul style="list-style-type: none"> Amount of concrete = 8.0748m^3 Cost of concrete for construction is $8.0748 \times 8400 = 67828.32$ There is no cost saving 	<ul style="list-style-type: none"> Amount of concrete = 5.905m^3 Cost of concrete for construction is $5.905 \times 8400 = 49602$ Cost saving is $67828.32 - 49602 = \text{Rs.}18226.32$

7. ADVANTAGES

7.1 Superior Statics

- Reduced weight
- Increased strength
- Larger span
- Fewer columns
- No beams or ribs under the ceiling.

7.2 Production & Carrying Out

- Good quality through automated production of prefabricated units
- Less work in situ; employment of unskilled labour
- Easier and more simple erection
- Less storage spaces

7.3 Safety

- Fire – Fireproof construction.
- Earthquake - Safety will benefit significantly alone from the weight reduction.
- Moisture - Condensation-safe construction.

7.4 Environmental Improvement

- Materials saved up to 50 % - 1 kg of plastic replaces more than 100 kg of concrete.
- Less energy consumption - both in production, transport and carrying out.
- Less emission - exhaust gases from production and transport, especially CO₂.

7.5 Transportation

- Transportation of materials is reduced considerably - lower costs and environmental improvement.

7.6 Economic Savings

- Savings in materials (slabs, pillars, fundaments) are substantial (up to 50%)
- Manual mounting of reinforcement meshes on the building site is avoided
- Transportation costs are heavily reduced
- Subsequent work (installations) are simplified
- Buildings are more flexible
- Changes are much less costly
- Life span of buildings is longer

8. CONCLUSION

The result identified that 1m³ of concrete replaced by high density polyethylene hollow sphere with 27% cost reduction in total amount of concrete. Bubble Deck will distribute the forces in a better way than any other hollow floor structures. Because of the three-dimensional structure and the gentle graduated force flow the hollow areas will have no negative influence and cause no loss of strength. All tests, statements and engineering experience confirm the obvious fact that BubbleDeck in any way act as a solid deck and consequently Will follow the same rules/regulations as a solid deck (with reduced mass). It Leads to considerable savings.

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