



Design of Voided Bubble Deck Slab

Harnisha Patel¹, Jaldhi Patel¹, Vasav Desai¹, Vatsal Desai¹, Shaikh Mohd Saquib²

¹ Students, Dept. of Civil Engineering, LIT – Sarigam, GTU – Ahmedabad, Gujarat, India

² Asst. professor, Dept. of Civil Engineering, LIT – Sarigam, GTU – Ahmedabad, Gujarat, India

Abstract--- Bubble deck slab is a slab which is created by inserting voids in the form of bubbles which reduces dead weight and is an eco-friendly practice. In this method, all the concrete which is not performing any structural function is removed. This reduces the dead weight of the structure. High density polyethylene hollow spheres are used which replace the in-effective concrete in the center of the slab. The advantages are reduced weight, savings in materials, faster construction time, less emission of exhaust gases and it is also a green technology. In this paper, we have designed a voided Bubble Deck Slab. The main aim is to design and estimate the quantities of various items. The overall cost of constructing the Bubble deck slab has also been determined.

Keywords – Bubble deck, Voided, Slab, Hollow slab, HDPE spheres

I. INTRODUCTION

Bubble deck slab is a biaxial hollow core slab invented in Denmark. 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 considerably 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. Bubble deck slab is constructed by placing prefabricated plastic bubbles and the reinforcement is then placed between and over plastic bubbles and lastly, fresh concrete is poured. The gaps leads to 30 to 50% lighter slab which reduces the loads on the columns, walls and foundations, and of course on the entire building. Bubble deck slab floor can offer the requisite load-bearing capacity at a smaller thickness. This leads to an additional advantage, resulting in a saving of 40 to 50 % of the material consumption in the floor construction. Since the weight of the structure is reduced, this type of structure can be useful to reduce earthquake damage.

II. LITERATURE REVIEW

Extensive literature study has been carried out from national and international journals. These literatures are classified as journals, documents collected from web etc. Abstracts of some literature are included here for the review.

2.1 Experimental study on bubble deck slab by Mr. Muhammad Shafiq Mushfiq, Shikha Saini, Nishant Rajoria

In this literature, slabs of three kind were tested, one without bubbles (conventional) and two with bubbles. Then they have compared the load bearing capacity of bubble deck slab with conventional slab. It was observed that the bubble deck slabs were not as efficient as the conventional slab, (having lesser load bearing capacity), but they are very much acceptable in slab construction keeping in view the trifling difference in load bearing capacity.

2.2 Study on Structural Behaviour of Bubble Deck Slab using Indian Standards by Immanuel Joseph Chacko, Sneha M. Varghese

In this paper, the authors have studied the structural behaviour of Bubble Deck Slab using Indian Standards by varying parameters like ball diameter variation. They have studied various factors such as load vs deflection characteristics and load vs strain characteristics and ultimate load. The specimens were tested on a 50 ton loading frame with a load cell of capacity 50 Ton.

2.3 An experimental study on two way bubble deck slab with spherical hollow balls by Bhagyashri G. Bhade and S.M Barelikar

In this paper, authors have compared different parameters between solid conventional slab and bubble deck slab. Parameters which have been compared include load carrying capacity, deflection behavior and weight of the slab. The tested slabs were simply supported and were loaded with a single point load.

III. DESIGN METHODOLOGY

The Direct Design Method has been used for designing this slab system. In this method, total moment is calculated and then it is distributed to total negative moment and total positive moment. All the negative and positive moments are distributed in the column strips and middle strips respectively.

3.1 Limitations

Slab system designed by the direct design method should accomplish the following conditions:

- There shall be minimum of three continuous spans in each direction,
- The panels shall be rectangular, and the ratio of the longer span to the shorter span within a panel shall not be greater than 2.0
- It shall be permissible to offset columns to a maximum of 10 percent of the span in the direction of the offset notwithstanding the provision in (b)
- The successive span lengths in each direction shall not differ by more than one-third of the longer span. The end spans may be shorter but not longer than the interior spans, and
- The design live load shall not surpass three times the design dead load.

3.2 Total Design Moment

In the direct design method, the total design moment for a span shall be determined for a strip bounded laterally by the centre-line of the panel on each side of the centre-line of the supports. The absolute sum of the positive and negative bending moments in each direction shall be taken as:

$$M_0 = \frac{WLn}{8}$$

Where,

M_0 = Total moment

W = Design load on the area L_2L_n

L_n = Clear span extending from face to face of columns, capitals, brackets or walls but not less than $0.65 L_1$

L_1 = Length of span in the direction of M_0 ; and

L_2 = Length of span transverse to L_1

3.3 Negative and Positive Design Moments

The total design moment M_0 in a panel is to be distributed into negative moment and positive moment as specified below:

In an interior span

Negative Design Moment = $0.65 M_0$

Positive Design Moment = $0.35 M_0$

In an end span

Interior negative design moment:

$$0.75 - \frac{0.10}{1 + \frac{1}{\alpha c}}$$

Positive design moment:

$$0.63 - \frac{0.28}{1 + \frac{1}{\alpha c}}$$

Exterior negative design moment:

$$\frac{0.65}{1 + \frac{1}{\alpha c}}$$

where αc is the ratio of flexural stiffness of the exterior columns to the flexural stiffness of the slab at a joint taken in the direction moments are being determined and is given by

$$\alpha_c = \frac{\sum K_c}{K_s}$$

Where,

K_c = Sum of the flexural stiffness of the columns meeting at the joint; and

K_s = Flexural stiffness of the slab, expressed as moment per unit rotation.

IV. PROBLEM STATEMENT AND LOAD CALCULATION

One of the most common components in modern building construction is reinforced concrete slab which consume a lot of concrete. Due to the sheer amount of concrete required to produce these slabs, the dead weight of these slabs tend to be very large. Lighter structures are more preferable to heavier structures in seismically active regions. In our project, we have discussed about the significance of Bubble Deck slab over traditional conventional slab. This method virtually eliminates concrete from the middle of the conventional slab, thereby dramatically reducing structural dead weight. Bubble Deck slab uses hollow spherical or elliptical balls made by recycled plastic. Plastic voided slabs are capable of reducing the amount of concrete necessary to construct a building by 30 percent or more. Voids in the middle of a flat slab eliminate up to 35% of a slab's self-weight removing constraints of high dead loads and short spans. This provides a wide range of cost and construction benefits.

4.1 Structural Loads

The loads acting on the slab may be categorized as:

- Dead Load
- Live Load
- Floor Finish

4.1.2 Dead Loads

Dead Loads, are those which are associated with the weight of the structure itself. These loads remain stationary and relatively constant over time.

Dead Load = Effective volume * Density of concrete * width

Effective volume = 0.24m^3

Width = 1000mm

Density of concrete = 25N/mm^2

Dead Load = $0.24 * 25$
 $= 6\text{kN/m}^2$

4.1.3 Live Load

Live Loads which are also known as applied or imposed loads or variable actions may vary over time. Live load is assumed in accordance with IS 875 (Part-II) - 1987

Live load = 4kN/m^2 | IS 875 (Part -2)

4.1.4 Floor Finish

Floor Finish = 1kN/m^2 | IS 875 (Part -2)

V. MODELLING AND DESIGN

5.1 Model Data

- Size of Panel = 21m x 21m
- Size of Column = 400mm x 400mm
- Floor to floor height = 3 m
- $f_{ck} = 25\text{ N/mm}^2$
- $f_y = 415\text{ N/mm}^2$
- Dead Load = 6 kN/m
- Live Load = 4 kN/m
- Floor Finish = 1 kN/m

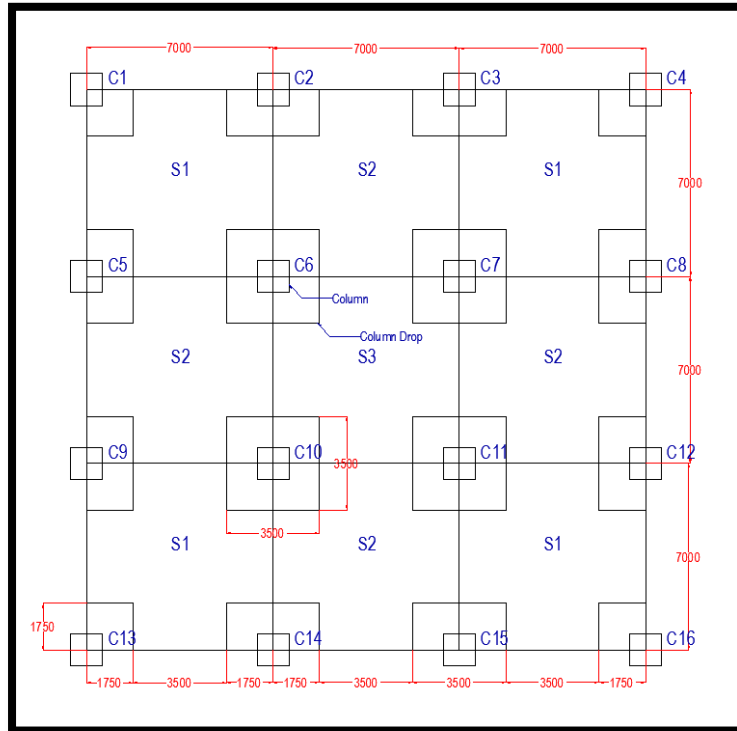


Figure 1: Structural Layout of the panel

5.2 Design of slab

Based on span and end conditions, the entire floor system can be grouped into 3 groups.

S1 = Corner Panel

S2 = Exterior Panel

S3 = Interior Panel

5.2.1 Design of Interior Panel (S3)

Reinforcement Details

$$A_{st \min} = \frac{0.12}{100} \times 1000 \times 225 = 270 \text{ mm}^2$$

$$D = 200 \text{ mm}^2$$

Strip	Moment	Ast	Bar Diameter	Spacing	Ast provided
Along X					
Zone 1	-60.54	906	12	120	942.42
Zone 2	26.079	372	12	300	376.9
Zone 3	-20.18	286	12	300	376.9
Zone 4	17.386	245.8	12	400	282.7
Along Y					
Zone 1	-60.54	906	12	120	942.42
Zone 2	-20.18	286	12	300	376.9
Zone 3	26.079	372	12	300	376.9
Zone 4	17.386	245.8	12	400	282.7

Table 5.1: Reinforcement Details for Interior Panel

5.2.2 Design of Corner Panel (S1)

Effective depth of slab = 200 mm

Effective depth of drop = 200 + 100 = 300 mm

Reinforcement Details

Strip	Moment	Ast	Bar Diameter	Spacing	Ast provided
Along X					
Zone 1 (exterior)	-41.14	599.88	12	150	753.9
Zone 1 (interior)	-65.11	982	12	100	1130.9
Zone 2	36.3	525.9	12	200	565.45
Zone 3 (interior)	-21.7	308.56	12	300	376.96
Zone 4	24.2	345.19	12	300	376.96
Along Y					
Zone 1 (exterior)	-41.14	599.88	12	150	753.9
Zone 1 (interior)	-65.11	982	12	100	1130.9
Zone 2 (interior)	-21.7	308.56	12	300	376.96
Zone 3	36.3	525.9	12	200	565.45
Zone 4	24.2	345.19	12	300	376.96

Table 5.2: Reinforcement Details for Corner Panel

5.2.3 Design of Exterior Panel (S2)

Reinforcement details

Strip	Moment	Ast	Bar Diameter	Spacing	Ast provided
Along X					
Zone 1 (exterior)	-34.75	502	12	200	565.45
Zone 1 (interior)	-64.5	972.1	12	110	1028
Zone 2	34.96	505.6	12	220	514.04
Zone 3 (interior)	-21.5	305.6	12	300	376.9
Zone 4	23.3	331.97	12	300	376.9
Along Y					
Zone 1 (exterior)	-34.75	502	12	200	565.45
Zone 1 (interior)	-64.5	972.1	12	110	1028
Zone 2 (interior)	-21.5	305.6	12	300	376.9
Zone 3	34.96	505.6	12	220	514.04
Zone 4	23.3	331.97	12	300	376.9

Table 5.3: Reinforcement Details for Exterior Panel

VI. ESTIMATION AND COSTING

6.1 Estimating the quantities of various items of work

6.1.1 Quantity of Concrete:

Volume of Concrete = $L \times B \times H = 21 \times 21 \times 0.225 = 99.225 \text{ m}^3$

Volume of bubble = $\frac{4}{3}\pi r^3 = \frac{4}{3}\pi 0.1125^3 = 0.00596 \text{ m}^3$

For 6530 bubble Volume = 38.92 m^3

Volume of Drop panel = $3.5 \times 3.5 \times 0.1 = 1.225 \text{ m}^3$

Volume of Concrete required = $99.225 - 38.92 + 1.225 = 61.53 \text{ m}^3$

6.1.2 Shuttering: Shuttering = 21×21
= 441 m^2

6.1.3 Weight of steel: The weight of steel has been calculated in the following categories:

- a) Exterior Panel Bottom Steel
- b) Exterior Panel Top Steel
- c) Interior Panel Bottom Steel
- d) Interior Panel Top Steel
- e) Corner Panel Bottom Steel
- f) Corner Panel Top Steel

Total Steel Required = $1362.87 + 364.96 + 22 + 312.02 + 2442.49 + 475.47$

= 4979.81 kg

6.2 Rate Analysis:

The following table show shows the total amount which will be required for construction of Bubble Deck slab.

Sr. No.	Description	Quantity	Rate	Per	Amount
1.	Concrete	61.53 m^3	4300	m^3	Rs. 2,64,579
2.	Shuttering work (material and labor)	441	450	m^2	Rs. 1,98,450
3.	Reinforcement	4979.81 kg	45	kg	Rs. 2,24,091
4.	Bubble	6530	7	Nos.	Rs. 45,710
5.	Labor for cutting, bending and tying reinforcement	4979.81	8	kg	Rs. 39,838.48
6.	Labor for laying of concrete	61.53 m^3	200	m^3	Rs. 12306
	Total				Rs. 7,84,974

Table 6.1: Rate Analysis

VII. CONCLUSION

Based on our study regarding Bubble Deck slab system, the following conclusions can be made:

- The Bubble Deck slab is a technology which helps us to cope up in the present scenario of the construction industries. These slabs are more economical, easy to construct and environment friendly.
- The volume of concrete required in Bubble Deck slab is less. This helps in the savings of materials.
- Weight reduction is an important factor which is found in Bubble Deck slab. Reduction in the use of concrete helps to reduce self- weight of the slab.
- It helps in saving of cost by using bubbles in the slab.
- The Bubble Deck technology is environment friendly and sustainable. It reduces the global CO_2 emissions.
- It requires skilled labour.
- The voids in the slab provide excellent thermal insulation property.
- It helps in saving time. Construction time can be shortened since Bubble Deck slabs can be precast. As there is considerable less concrete content in the slab, the casting time is quicker.

VIII. REFERENCES

1. **“Experimental Study on Bubble Deck slab”**, International Research Journal of Engineering and Technology (IRJET), Volume:04 Issue:05|May 2017, e-ISSN:2395-0056
2. **“An Experimental Study on Two Way Bubble Deck Slab with Spherical Hollow Balls”**, International Journal of Recent Scientific Research (IJRSR), Vol. 7, Issue 6, ISSN:0976-3031
3. **“Study on Structural Behavior of Bubble Deck Slab using Indian Standards”**, International Journal of Innovative Research in Technology (IJIRT), Volume 3, Issue 4, ISSN: 2349-6002
4. **“To study Comparison between Conventional Slab and Bubble Deck Slab”**, International Advanced Research Journal in Science, Engineering and Technology (IARJSET), Vol. 5, Issue 1, ISSN 2393-8021
5. **“Structural Behavior on two way Bubble deck slab using hollow spherical balls”**, Vishwakarma Journal of Engineering and Research (VJER), Volume 1, Issue 2, ISSN : 2456-8465
6. **“Comparative study of Bubble Deck slab and Solid Deck slab”**, International Journal of Advance Research in Science and Engineering (IJARSE), Vol. 6, Issue 10, ISSN: 2319 -8354
7. IS 456:2000, Indian Standard Plain and Reinforced Concrete – Code of Practice
8. IS: 875 (Part 2) – 1987, Indian Standard Code of Practice for Design Loads for Buildings and Structures
9. <http://www.bubbledeck-uk.com>
10. <https://theconstructor.org>
11. <https://www.engineeringcivil.com>