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DESIGN AND EXPERIMENTAL ANALYSIS OF BUBBLEDECK SLAB

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ABSTRACT

Bubble deck, which is another name for voided slabs whose core is placed with HDPE balls that may be of different shapes and sizes is a technology that is presently procuring awareness around the world as a result of its enormous positive effects on the whole structure; this include its reduced weight, economical and mutability in terms of slab span. This research work has focused on the use of bubble deck in construction industry. Concrete grade of M35 was used.

Two slabs were casted, one with HDPE Balls and the other without balls. The slab without HDPE balls (conventional slab) was casted with (78.13 kg) of concrete. On the other side the slabs with bubbles, which has spherical balls of size 60mm in which (63 kg) of concrete was used with B/H ratios of 0.48 and 49 spherical balls respectively. A total 24% of concrete was saved in the Bubble Deck slab. Considering the percentage of concrete saved, one slab was designed usually and in another a 24% reduction in dead loads was assumed and further designed was carried out. Costing of both the slab was carried out and comparison was done. In experimental analysis, destructive and non-destructive test was carried out on both the slabs and result has been compared

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Key Words: RCC Slab, HDPE Balls, Reinforcement mesh.

1.0 INTRODUCTION

The major role in construction sector is usually played by concrete only. Usually the middle portion of slab carried no load and in that part the concrete is not useful. Reduction of concrete in the middle portion of the slab can be achieved by providing HDPE Balls .To increase the efficiency of floor and to decrease the unwanted concrete in slab this type of technology would be very suitable.

Bubble deck slab is a technology which substitute the unwanted concrete by the HDPE Balls. This slab uses hollow spherical surface rigid balls made by high density plastic and therefore it is an inventive technique of effectively eliminating the concrete in the central part of conventional slab which does not contribute to the structural self-weight and also leads to 25 to 40% lighter slab which reduces the loads on the columns, walls and foundation, and of course of the entire structure.

There are total three versions of Bubble deck slab- filigree elements, reinforcement modules, and finished planks. Fig no.1 shows the typical layout of Bubble deck slab.

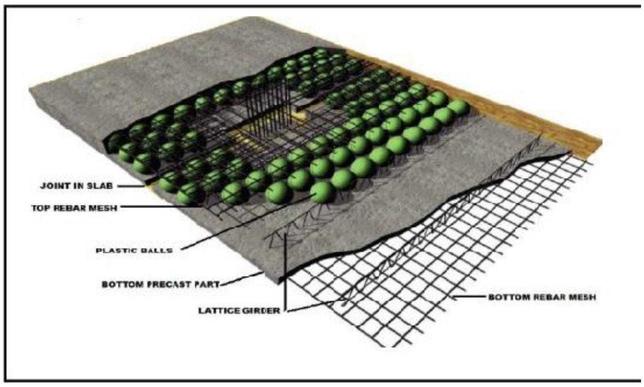

Fig No. 1 Typical Layout of Bubble deck slab

2.0 OBJECTIVES

- To design and compare both the conventional slab and Bubble deck slab
- To cast both the conventional slab and Bubble deck slab
- To find out the ultimate load carrying capacity of both the slabs.
- To study the bending strength of Both the slabs.
- To study the strength and porosity of both the slabs.
- To Compare the costing of both the slabs to find out the economic benefits.

3.0 LITERATURE REVIEW

1) **John Rutherford (1990):** Researchers studied that the voided concrete slabs have been around for decades, and although designs might vary the technology behind them remains the usual. More recently, the idea of cast-in-situ voided slabs has become a dramatic choice for designers and architects looking to reduce slab thickness and overall structure load. This growing enthusiasm can be attributed to the architectural need for larger spans and higher ceilings, more experience with and confidence in the product, and the push for sustainable design in the industry. Bubble deck slab systems are prominently lighter than normal concrete slabs while maintaining the ability to have large spans.

2) **Md Irfan Chaudhry, Vishwajeet Sinha and Dr. Rupesh Shelke (1995):** Bubble deck slab is a Cast in-situ slab which is Formed by inserting voids in the form of hollow plastic balls which reduces self-weight and is an environment friendly. Environment has become the greatest fact of concern by the disposal of Plastic Waste. By using recycling plastic various sizes of HDPE balls can be formed. to create an eco-friendly atmosphere, recycling of plastic waste plays a significant role.

3) **Jorgen Bruenig (2000):** The first biaxial hollow slab is invented by Jorgen Bruenig in Denmark. Bubble deck provides a much durable construction option by using less concrete than Conventional concrete floor systems and also contributes less CO2 emission to the above atmosphere in the manufacturing process. Recycled plastic balls helps to meet the sustainability Goals. The spheres could be recycled even after the building is demolished in the upcoming future cause of the renewal development. To achieve the 30 to 50% lighter slab it can virtually eliminate the concrete part in the middle of the slab which also reduces the load on columns, walls, foundations and the entire course of the building. Bubble deck slab is a modernized flooring system of reinforced concrete, which contains spherical hollows as concrete saving elements.

4) **Lakshmikanth, P. Poluraju (2017):** In this paper the authors have studied that a concrete contains around 2-3% vol. of air voids that are unnecessary chucked up because of poorly compaction. Air entrainment admixture can

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deliberately have incarnated the air voids which is also a suitable surfactant. The damages by the repeated exposure of Freeze-thaw cycles and salt scaling can be prevented by the air entrainment agents. Ten and hundreds of microns are the sizes of entrained agents. To ensure significant frost protection, the spacing of the air voids should not be greater than a critical distance, typically 300-350 µm. However, for simplicity and ease, most standards describe the whole air content by pretending that the spacing factor is directly proportional to air content.

5) **Rittik Bhowmik, Sourish Mukherjee, Aparna Das (2020):** Researchers studied that the HDPE Balls are much effective cause of its less weight but might create problems because of its slighter porous property. Due to the tear-wear effect over a certain period of time the ball might leave water behind and may result in decaying of the structures. Still using this technique would prove less costly as the material is available in abundance and using the recycling balls is easy but little bit costly.

4. MATERIALS

Cement: Ordinary Portland cement of grade 53 was used as a hydrated paste is the binder of concrete. High strength and durability would be achieved by this type of cement. Specific gravity bottle was used to find out the specific gravity of the cement and it was 3.15.

Fine Aggregate: Crushed sand size 4.75mm and below confirming to zone 2 of IS 383-1970 is being used as the fine aggregate.

Table 1: Physical characteristics of fine aggregates

Testing	Results
Fineness modulus	3.10
Specific gravity	2.7

Coarse aggregate: Coarse aggregates of size 10mm and 20mm was used as a Voids filler.

Table 2: Physical properties of Coarse aggregates

Testing	Results
Fineness modulus	3.25
Specific gravity	2.6

HDPE Balls: High density poly-propylene Balls of diameter 60 mm were used in this project. The balls were rigid and has a rough surface textures. To curb the consumption of finite natural resources such as oil and minimize the burden on the environment was the main purpose of the recycled.

Fig No.2 HDPE Balls

Steel Reinforcement: HYSD BARS of grade 550 steel were used as reinforcement. The same grade of steel is generally used in both the slabs. The diameter of main and distribution was 8mm and 10mm respectively. Only bottom reinforcement was used not any top unlike others. The spacing of bars was 75mm for both the bars. Wire mesh can be used if facing the problem during placing the balls.

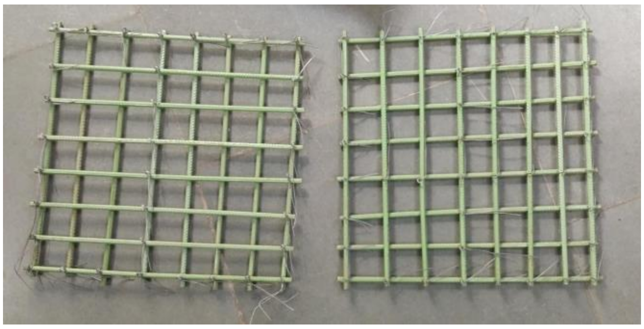

Fig No.3 Steel reinforcement

Formwork materials: To cast the concrete in particular shape there would be some temporary mould that is called as formwork. Two formwork of size 500x500x125 were made and the material was totally water-proof to avoid the loss of water from the concrete. All fastens screw were used to achieve the rigidity of mould so there won't be any problem during compaction.

Fig N0.4 Formwork

Water: Potable water of ph. (6.6-8.5) was being used for both mixing and curing. The water should be free from the excess sulphides and chlorides. Concrete properties like workability, permeability, water tightness, durability and drying shrinkage, etc. would be fluctuate or vary depending on the quality of water being used. Due to such reasons its very necessary to control the quality of water for durability and sustainability reason.

5. METHODOLOGY

The various works done are given below:

- Design of both conventional and Bubble deck slab.
- Cost Comparison of both the slab based on their design.
- M35 grade concrete is selected and designed was carried out.
- Casting of both the slab with M35 grade concrete.
- Using Universal testing machine (UTM) three point load test is conducted.
- Ultrasonic pulse velocity test was carried out to determine the porosity of both the slabs.
- Result analysis and comparison of conventional slab and bubbledeck slabs.

6. EXPERIMENTAL STUDIES

A. Experimental procedure

6.1 Load-Deflection test:

Two types of slab were casted one was conventional and the other was bubble deck slab. 500mm x 500mm x 125mm were the size of both the slabs. Simply supported with a hinge support at one end and roller support at other end. Specimens were tested in UTM by applying three-point load over the top portion of slab. The maximum loading capacity of hydraulic jack was 2000KN and the load was gradually increased with the interval of 5KN, the hydraulic jack is adjusted with the force same as the self-weight of the slab. Strain gauge was used to measure the deflection which was adjusted in such a way that the mid span deflection would be carried easily. The loading was done until any cracks were seen till that the readings were taken into consideration.

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Fig No.5 Three-point load testing on slab

6.2 Ultrasonic pulse velocity Test:

The non-destructive test is to determine the quality of concrete structures. An ultrasonic pulse is passed through the concrete and it is assessed by measuring the distance with time. Good quality of concrete would be denoted by higher velocities while bad quality with many cracks can be determined by the slower velocities.

Two direct and two indirect readings were taken which makes total 8 reading on both the slabs. Velocity below than 3.0Km/sec indicates poor quality and more than 4.40Km/sec indicates Excellent quality.

Fig No. 6 UPV Test

7.TEST RESULTS AND DISCUSSIONS

Table 3: Load - deflection Test

SR.NO	Load in KN	Deflection (CV) in mm	Deflection (BD) in mm
1	0	0.0	0.0
2	10	0.40	0.41
3	15	0.55	0.56
4	20	0.86	1.41
5	25	1.01	1.52
6	30	1.20	1.56
7	39.8	1.35	1.72

The maximum load at which the Bubble deck slab started showing cracks was 39.8KN at which Point the deflection was found to be 1.72mm. In the case of conventional slab the deflection was found to be 1.35mm at same load that is carried by the Bubble deck which is 39.8KN.

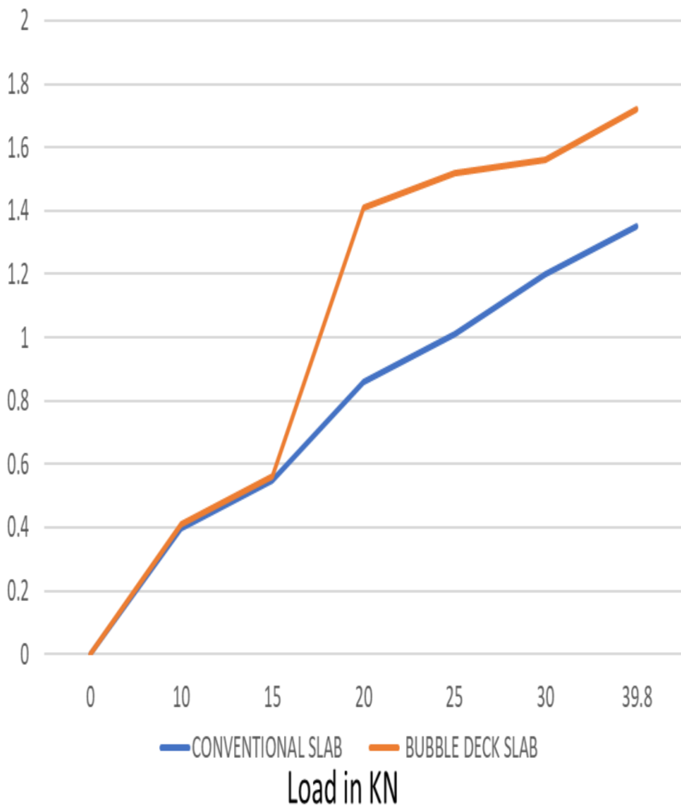

Fig No.7 Load-Deflection Curve

The results obtained from the test confirmed the fact mentioned in the research papers referred and showed that though the Bubble deck slab deflected slightly more than the conventional slab but it was under the limit as prescribed in IS 456 i.e. 20mm.

Table 4: Ultra Sonic Pulse Velocity Test

SR.NO	Location	Distance (mm)	Time (Micro sec)	Velocity (Km/sec)	Method
	C.V				
1	Point no 1	500	109.10	4.58	Direct
2	Point no 2	500	110.20	4.54	Direct
3	Point no 3	400	97.30	4.11	Indirect
4	Point no 4	400	98.70	4.05	Indirect
	B.D				
1	Point no 1	500	115.10	4.34	Direct
2	Point no 2	500	112.20	4.46	Direct
3	Point no 3	400	110.00	3.64	Indirect
4	Point no 4	400	120.80	3.31	Indirect

Based on the ultra-sonic pulse velocity test, the result confirmed that the conclusions of the previous research papers. When the test was performed by direct method the average result in case of conventional slab was found to be 4.56 while for bubble deck slab the value obtained was 4.4. when the test was performed by indirect method the result obtained for conventional slab was 4.08 and for bubble deck slab it was 3.475.

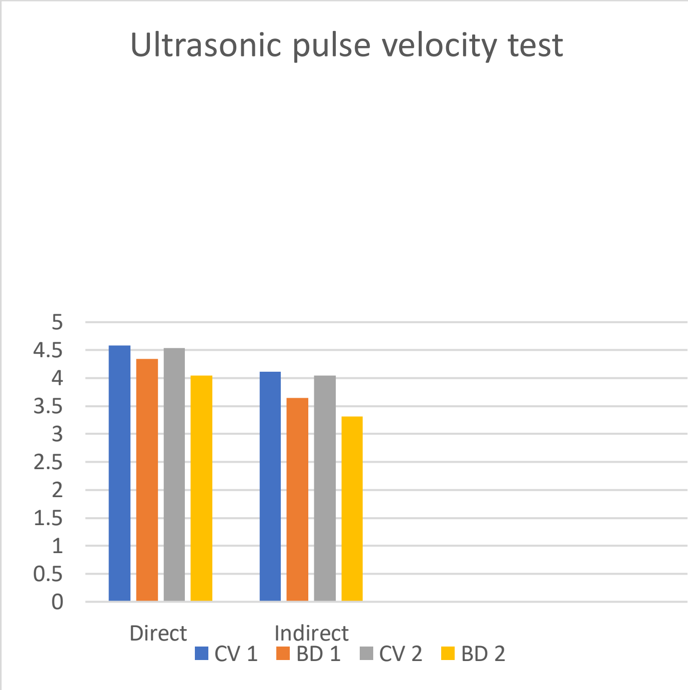

Fig No.8 Ultra pulse velocity Bar chart

8. CONCLUSION

1. To evaluate the structural behavior of the Conventional slab and Bubble deck slab the test was conducted according to the IS standards.
2. The experiment was carried out using loading frame by applying the UDL load over the slab to know the ultimate load carrying capacity and deflection.
3. when compared to conventional slab the bubble deck slab withstands 90% of load carrying capacity as of it.
4. The weight reduction of 25% in bubble deck slab compared to conventional slab is obtained. The UPV result was achieved to be in the range of good & excellent in both the slab.
5. The deflection observed for the bubble deck slab is 1.72mm at 39.8KN and 1.35mm at 39.8KN for the conventional slab which is within the permissible limit i.e. 20mm.Reduction of self weight in slab leads to 17.83% of cost reduction.

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