



## IJRTSM

### INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

#### “COMPARATIVE STUDY OF SPHERICAL BUBBLE INFUSED CUBE AND NORMAL CUBE”

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#### ABSTRACT

*Bubble Deck is a revolutionary method of virtually eliminating concrete from the middle of conventional slab which does not perform any structural function, thereby dramatically reducing structural dead weight by linking air and steel directly. Bubble Deck slab uses hollow spherical or elliptical balls made by recycled plastic. A Bubble Deck slab has a two-dimensional arrangement of voids within the slabs to reduce self-weight. The behaviour of Bubble Deck slabs is influenced by the ratio of bubble diameter to slab thickness. This new prefabricated construction technology is recently applied in many industrial projects in the world. This shows the effectiveness and feasibility of the application of Bubble Deck in the construction. Voids in the middle of a flat slab eliminate 35% of a slab's self-weight removing constraints of high dead loads and short spans. Combination of recycled plastic bubbles permits 50% longer spans between columns without any beams. This provides a wide range of cost and construction benefits. Usually the Bubble Deck system combines the benefits of factory-manufactured elements in controlled conditions along with on-site completion with the final monolithic concrete, resulting in a completed floor slab. This paper presents a study on the properties and advantages of Bubble Deck slab system. Bubble Deck technology is implemented in this project using Indian Standards and Indian codal Provisions (IS 456:2000) which has not been experimentally tested to-date. The major benefit of this project is that it makes use of non-degradable waste plastic thus a very eco-friendly practice.*

*Experimental results of the above project shows that there is no much reduction in strength and various aspects compared to normal reinforced concrete slab. Hence this is a highly innovative practice that can be implemented using Indian Standard codes which has not yet implemented in the Indian scenario.*

**Keyword:** Bubble deck slab, HDPE Balls, Aggregate.

#### I. INTRODUCTION

In building constructions, the slab is a very important structural member to make a space. And the slab is one of the largest member consuming concrete. Bubble Deck is the invention of Jorgen Bruenig in 1990's, who developed the first biaxial hollow slab (now known as Bubble Deck) in Denmark. This new prefabricated construction technology using Bubble Deck slab is recently applied in many industrial projects in the world. Bubble Deck slab uses hollow balls made by recycled plastic and therefore it is an innovatory method of virtually eliminating the concrete part in the middle of conventional slab which does not contribute to the structural performance. This hence reduces significantly the structural self-weight and also leads to 30 to 50% lighter slab which reduces the loads on the columns, walls and

foundations, and of course of the entire building. Bubble Deck uses less concrete than traditional concrete floor systems; it offers a more sustainable construction option, contributes less CO<sub>2</sub> to the atmosphere in the manufacturing process and also meets sustainability goals through the use of recycled plastic spheres. The spheres could be recycled even after the building is demolished or renovated in the future. The dead air space in the hollow spheres provides insulating value and can be introduced with foam for additional energy efficiency. Therefore, the Bubble Deck has many advantages as compared to traditional concrete slab, such as: lower total cost, reduced material use, enhanced structural efficiency, decreased construction time, and is a green technology. The reinforcements are placed as two meshes one at the bottom part and one at the upper part that can be tied or welded. The distance between the bars are kept corresponding

to the dimensions of the bubbles that are to be embodied and the quantity of the reinforcement from the longitudinal and the transversal ribs of the slab. The two-way concrete slab system was developed in Denmark and was first used in Holland. It became an integral part of the Millennium Tower which was built to celebrate the new millennium. Now, the Bubble Deck technology gains much of attention from engineers and researchers from the world.

## II. MATERIAL

- (A) **Hollow bubbles:** The bubbles are made using high density polypropylene materials. These are usually made with nonporous material that does not react chemically with the concrete or reinforcement bars. The bubbles have enough strength and stiffness to support safely the applied loads in the phases before and during concrete pouring. Bubble diameter varies between 65mm to 450mm. Depending on this; the slab depth is 150mm to 600mm. The distance between bubbles must be greater than 1/9th of bubble diameter. The nominal diameter of the gaps may be of: 180, 225, 270, 315 or 360 mm. The bubbles may be of spherical or ellipsoidal in shape.
- (B) **Concrete:** The concrete used for joint filling in the Bubble Deck floor system must be above class 20/25. Usually self-compacting concrete is used, either for the casting of prefabricated filigree slab, or for the joint filling on the site. 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. The nominal maximum size of the aggregate is the function of thickness of the slab. The size should be less than 15mm. M25 Grade and above should be used.
- (C) **Reinforcement bars:** The reinforcement of the plates is made of two meshes, one at the bottom part and one at the upper part that can be tied or welded. The steel is fabricated in two forms - the meshed layers for lateral support and diagonal girders for vertical support of the bubbles. The distance between the bars are corresponding to the dimensions of the bubbles that are to be used and the quantity of reinforcement from transverse ribs of the slab.

## III. METHODOLOGY

Three The aim of the present investigation is to study the basic strength difference, strain, defection, crack pattern, dead weight and cost analysis of Bubble Deck slab with that of Normal Reinforced Concrete Slab. Study on bubble deck slab was based on the placing balls across the entire slab and comparing the properties with Normal RCC Slab (NRC). The same included comparison with variations in ball diameters. The ball diameter variations were 60mm to 65mm (S65 to S60). For the testing of the same, various properties of the materials used in concreting were also studied. The basic test on cement and aggregates were done, is given in table no.1

Table: 1 Test on Cement &amp; Aggregate

	Test for	Observed Value
Cement (OPC 53 Grade)	Specific Gravity	3.2
	Standard Consistency	34%
	Initial Setting Time	2%
	Final Setting Time	50 mins
	Fineness	275 mins
	7day Compressive Strength	40 N/mm <sup>2</sup>
Fine Aggregate	Specific Gravity	2.95
	Sieve Analysis	Zone I
Coarse Aggregate (Max size 20mm)	Specific Gravity	2.91
	Water absorption	0.1 %
	Crushing Strength	28.58%

**Casting of specimens& Curing of Specimens**

Specimens of size 1.5m x 1.5 m x 0.15m was casted as given in table 3. Wooden form works were used for concreting. Braces were given to formwork for extra support. Concreting was done on flat concrete floor. Plastic sheets were provided along the sides to prevent bleeding. A needle vibrator was used for compaction. Curing was done by method of ponding

Table: 2 Quantity of Cement required per specimen

Slab Notation	Specimen type	No of Balls	Total volume m <sup>3</sup>	Total Quantity of cement Req. for slab (Kg)
NRC	Normal RCC		0.27	124.77 kg
S65	Slab with full ball – 60mm	100	0.224	103.51 kg

The main objective of this project is to study the structural behaviour of Bubble Deck Slab as compare to normal slab using Indian Standards. Due to unavailability of equipment a samples of concrete cube (both normal and bubble ball used) are casted on a place of slab.

#### Casting of cubes:

The cube mould plates should be removed, properly cleaned assembled and all the bolts should be fully tight. A thin layer of oil then shall be applied on all the faces of the mould. It is important that cube side faces must be parallel. After taking concrete samples and mixing them, the cubes shall be cast as soon as possible. The concrete sample shall be filled into the cube moulds in 3 layers and balls

are placed inside the mould each layer approximately 5 cm deep. In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould. Each layer shall be compacted by hand. Each layer of the concrete filled in the mould shall be compacted by not less than 35 strokes by tamping bar. The strokes shall be penetrating into the underlying layer and the bottom layer shall be rodded throughout its depth. Where voids are left by the tamping bar the sides of the mould shall be tapped to close the voids.

#### Compressive strength test :

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
2. Clean the bearing surface of the testing machine
3. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
4. Align the specimen centrally on the base plate of the machine.
5. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
6. Apply the load gradually without shock and continuously at the rate of 140 kg/cm<sup>2</sup>/minute till the specimen fails
7. Record the maximum load and note any unusual



Fig: 1 Test of Specimen

#### IV. RESULT AND OBSERVATION

Size of the cube = 15cmx15cmx15cm

Area of the specimen = 225 cm<sup>2</sup>

Compressive strength = Load in N/ Area in mm<sup>2</sup>

Table: 3 compressive strength of a sample

TYPE OF CUBES	MARKING	COMPRESSIVE STRENGTH AFTER 7 DAY	COMPRESSIVE STRENGTH AFTER 14 DAY	COMPRESSIVE STRENGTH AFTER 28 DAY
BUBBLE CUBES	B1	10.18	15.48	18.22
	B2	10.66	15.11	17.77
	B3	9.92	14.73	17.33
NORMAL CUBES	C1	11.46	16.24	19.11
	C2	11.46	16.24	19.11
	C3	11.32	16.04	18.88

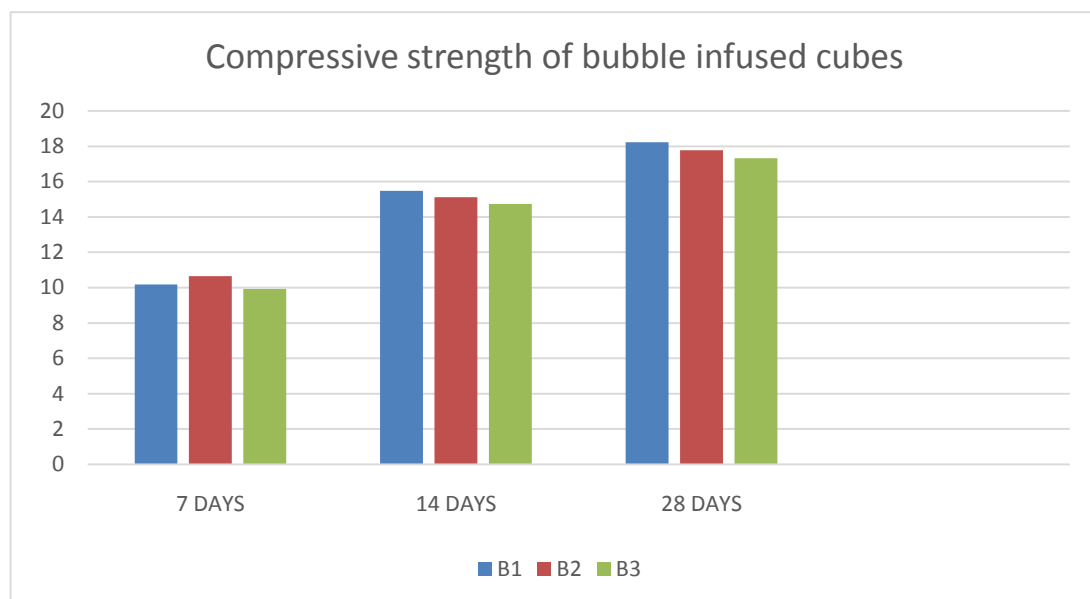
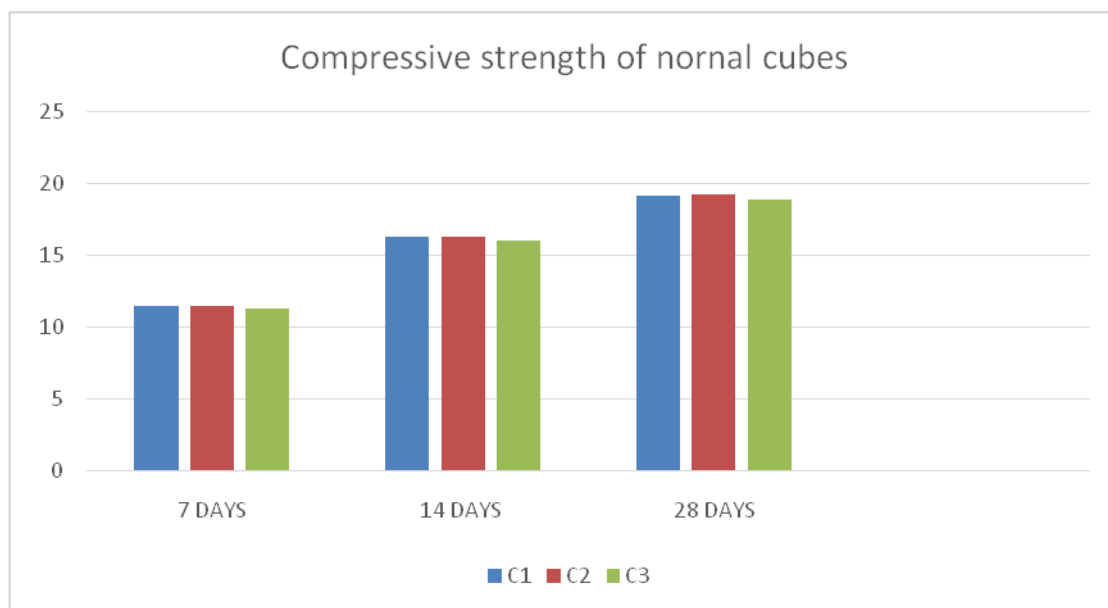


Fig: 2 Graph of bubble infused cube compressive strength



#### V. COST ANALYSIS

Cost analysis can be done on the basis of volume of material use and their market value

**For normal cubes :**

Table: 4 Cost analysis for normal cubes			
MATERIAL USE	QUANTITIES IN m <sup>3</sup>	RATE PER m <sup>3</sup>	COST OF MATERIAL
CEMENT	0.27	320	86.4
AGGREGATE	0.414	620	256.68
SAND	0.81	270	218.7
RAINFORCEMENT	3x10 <sup>-4</sup>	40 per kg	9.53
TOTAL COST			571.31

**For bubble infused cubes**

Table: 5 For bubble infused cubes

MATERIAL USE	QUANTITIES IN $m^3$	RATE PER $m^3$	COST OF MATERIAL
CEMENT	0.178	320	56.96
AGGREGATE	0.273	620	169.26
SAND	0.53	270	143.1
RAINFORCEMENT	$0.3 \times 10^{-3}$	40 per kg	9.53
BUBBLE BALL	$1.15 \times 10^{-3}$	75 per ball	75
TOTAL COST			453.85

**VI. CONCLUSION**

Bubble deck slab technology has been experimented in many parts of the world using international codes and standards. The Indian Standard Code was used for the design of cubes and bubbles were implemented into it. The results of the project show that there is very minute percentage comparable difference in properties compared to normal RCC cube which concludes that Bubble Deck slab can be implemented using the Indian Standard code (IS 456 : 2000).

On study, it can be concluded that

1. On the basis of results it is concluded that compressive strength of both normal cube and bubble infused cube are nearly same.
2. Advantage of Bubble infused system is the significant cost saving, results show that bubble infused cube is 70% of cost of normal cube.
3. By using the hollow elliptical balls, the better loadbearing capacity in Bubble infused can be achieved.
4. Concrete usage is reduced as 1 kg of recycled plastic replaces 100 kg of concrete. This avoids the cement production and allows reduction in global CO<sub>2</sub> emissions. Hence this technology is environmentally green and sustainable.
5. Reducing material consumption made it possible to make the construction time faster, to reduce the overall costs. Besides that, it has led to reduce dead weight up to 50%, which allow creating foundation sizes smaller.

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