Voided Slab

Abhay M. Pande, Anup M. Bhendale, Dr. Manish M. Bais

Civil Engg Departmeent, Sant Gadge Baba Amravati University, Amravati, Maharashtra, India

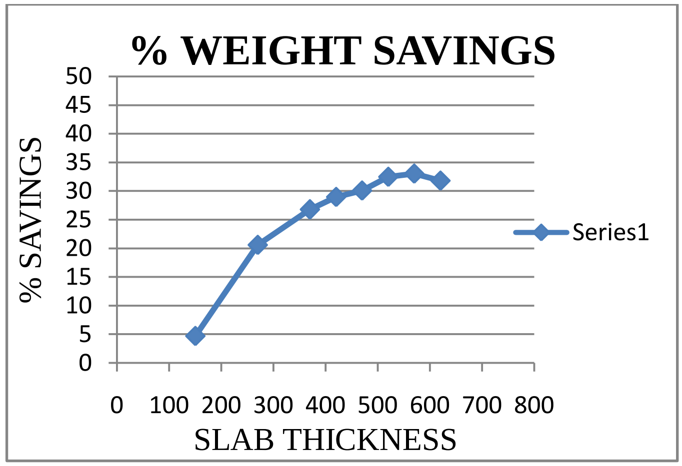
Abstract **-The present report discusses the various structural behavior of voided slab or bubble deck slab and their structural benefits over traditional concrete slab. Bubble deck slab is a method of virtually eliminating all concrete from the middle of a floor slab, which is not performing any structural function, thereby dramatically reducing structural dead weight. High density polyethylene hollow spheres replace the ineffective concrete in the center of slab, thus decreasing the dead weight and increasing the efficiency of the floor. A biaxial hollow slab system is widely known as one of the effective slab system which can reduce the self - weight of slabs. By introducing the gaps leads to a 30 to 40 % lighter slab which reduces the loads on the columns, walls and foundation, and of course of the entire building. A Bubble Deck slab has two dimensional arrangements of voids within the slab to reduce self-weight. The behavior of Bubble Deck slabs is influenced by the ratio of bubble diameter to slab thickness.**

***Keywords*— weight reduction, reduction in thickness**

I. INTRODUCTION

The voided slabs are reinforced concrete slabs in which voids allow to reduce the amount (volume) of concrete. In building construction, slab is very important structural member to make a space. And the slab is one of the largest member consuming concrete. The main obstacle with concrete constructions, in case of horizontal slabs, is the high weight, which limits the span. For this reason major developments of reinforced concrete have focused on enhancing the span reducing the weight or overcoming concrete's natural weakness in tension. In a general way the slab was design only to resist vertical load. However recently due to more use at domestic level slabs are subjected to more noise and vibration, so to minimize it there is need to increase the thickness which ultimately result in increased weight of slab. Increasing the slab thickness makes the slabs heavier, and will increase column and foundation size. Thus, it makes buildings consuming more materials such as concrete and steel reinforcement. To avoid these disadvantages which were caused by increasing of self-weight of slabs, the voided slab system is used.

The Bubble Deck method for the two direction reinforced composite concrete slab with gaps was inverted in Denmark, it is licensed and it was conceived to achieve saving of concrete and energy in building construction. The composite slabs are made of Bubble Deck type slab elements with spherical gaps, poured in place on traversal and longitudinal direction.



II. LITERATURE REVIEW

The use of flat plate slab is gaining much popularity amongst architects, because the flat plate slab system provides a way for the architect to achieve the concept of high and completely flat ceiling with no beam. As we know that, slab is one of the largest members consuming concrete, when the load acting on the slab is large 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 self-weight of slab is increase. To avoid these disadvantages various studies carried out and researchers suggest voided flat plate slab system to reduce the self-weight of the slab.

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. The main obstacle with concrete constructions, in case of horizontal slabs, is the high weight, which limits the span. For this reason major developments of reinforced concrete have focused on enhancing the span reducing the weight or overcoming concrete's natural weakness in tension. In a general way, the slab was designed only to resist vertical load. However, as people are getting more interest of residential environment recently, noise and vibration of slab are getting more important, as the span is increased; the deflection of the slab is also increased. Therefore, the slab thickness should be increase. Increasing the slab thickness makes the slabs heavier, and will increased column and foundations size. Thus, it makes buildings consuming more materials such as concrete and steel reinforcement. To avoid these disadvantages which were caused by increasing of self-weightof slabs, the voided slab system, was suggested.

III. THEROTICAL ASPECTS

Shear Strength:-

Shear strength of slab mainly depends on effective mass of concrete, as the special geometry shaped by the ellipsoidal voids acts like the famous roman arch, hence enabling all concrete to be effective. This is only valid when considering the bubble deck technology. Due to use of plastic bubbles, the shear resistance of bubble deck greatly reduces in comparison of solid slabs. The results of a number of practical tests confirm that the shear strength depends on the effective mass of concrete. The shear capacity is measured to be in the range of 72-91% of the shear capacity of a solid deck. Areas with high shear loads need therefore a special attention, e.g. around columns. That is solved by omitting a few balls in the critical area around the columns, therefore, giving full shear capacity.

Bending Strength:-

The bending strength is same for both bubble deck and solid slab and that the stiffness of bubble deck is slightly lower. Bending stresses in the bubble deck slab are found to be 6.43% lesser than that of solid slab. The ultimate load value obtaining bending tests were up to 90% greater than the ultimate load value. The bottom reinforcement steel and the top compressive portion of stress block contribute to flexural stiffness in the bending.

Fire Resistance:-

The fire resistance of slab is a complex matter but is chiefly dependent on ability of the steel to retain sufficient strength during a fire when it will be heated and lose significant strength as the temperature rises. The temperature of the steel is controlled by fire and the insulation of the steel from the fire. In any case, all concrete is cracked, and in a fire, it is likely that the air would escape and the pressure dissipated. If the standard bubble material is used (HDPE), the products of combustion are relatively benign, certainly compared to other materials that would also be burning in the vicinity. In an intense, prolonged fire, the ball would melt and eventually char without significant or detectable effect. Fire resistance depends on concrete cover nearly 60-180 minutes. Smoke resistance is about 1.5 times the fire resistance.

Vibration:-

Reinforced concrete slab structures are generally less susceptible to vibration problems compared to steel framed and light weight skeletal structures, especially using thin slabs. However bubble deck slab is light and is not immune from vibration in all cases so this must be checked just as it should be in appropriate solid slab applications. Where deflections are large, as indicated by the static design, it is often an indication that the structure is sensitive to vibrations.

IV. METHODOLOGY

COBIAX Technology

In Cobiax system, decks form the bottom of the slab, and the bottom layer of reinforcing steel must also be placed. The voids are locked in steel wire meshes which can be altered to fit the particular application (Corey, 2013). The top layer of steel reinforcement can be placed after the bundles are in place. Concrete is then poured in two lifts. The first concrete pour covers the bottom reinforcement and a portion of the voids and holds the voids in place as the concrete becomes stiff. The second lift is poured after the first lift is stiff but still fresh, finishing the slab. This method requires more formwork and on-site labor, but requires less transportation of materials.

Cobiax Technology is based on generating specific hollows inside a reinforced concrete slab. Massive concrete is replaced by synthetic void formers and remains only in statically relevant areas. Thus, it is possible to construct buildings with flat slabs while allowing for remarkable span width.

U-BOOT Technology

U-boot is a voided slab system which uses recycled polypropylene formwork designed to create two-way voided slabs and rafts. These void formers create many "I" shaped beams making up the slab (U-boot Beton, 2011). The U-boot system is cast entirely On-site using formwork. After forms are erected, the steel and void formers are placed before the concrete is poured in two lifts. In addition, this system is advantageous because the shape of U-boot void formers allows them to be stacked efficiently during transportation to the site, saving space and potentially leading to reduced shipping costs compared to spherical former systems (Corey, 2013).

BUBBLE DECK Technology

Bubble Deck is a plastic void system which comes in three forms- a precast filigree element, reinforced modules and finished planks (Nasvik, 2011).The revolutionary Bubble Deck method virtually eliminates concrete from the middle of a slab not performing any structural function, thereby dramatically reducing structural dead weight.

IV. DISCUSSION

Weight Reduction

Dimension of One way Slab = 0.3 M X 0.75 M

Dimension of Two way Slab = 0.6 M X 0.6 M

Thickness of Slab = 0.15 M ….. (For both slabs)

Volume of Concrete = (0.3 X 0.75 X 0.15) + (0.6 X 0.6 X 0.15) = 0.0877 M^3

No of Balls Used = 24

Diameter of each ball = 69 MM

Volume of ball = $24 \times \frac{4}{3} \times \Pi \times r^3$

$$24 \times \frac{4}{3} \times \Pi \times 34.5^3$$

$$4128165.844\ MM^3$$

$$0.00413\ M^3$$

Volume of Concrete (with ball) = 0.0877 – 0.00413 = 0.08357 M^3

Weight of Concrete (with ball) = 0.08357 X 25 = 2.089 KN =208.9 KG

Weight of Concrete (without ball) = 0.0877 X 25 = 2.192 KN =219.2 KG

Weight Reduction = $100 - \frac{208.9}{219.2} \times 100 = 4.7$ %

Cost Analysis

Volume of Concrete (wet volume) = 0.0877 + 0.52 X 0.0877 = 0.133 M^3

Weight of Cement = 50 KG

Weight of Sand = 87 KG

Weight of Aggregate = 175 KG

Approximate Cost = 340 + 200 + 400 = 940/-

Volume of Concrete (wet volume with ball) = 0.133 – 0.00413 = 0.129 M^3

Weight of Cement = 45 KG

Weight of Sand = 83 KG

Weight of Aggregate = 166 KG

Cost of Balls = 300

Approximate Cost = 320 + 160 +350 + 300 = 1130/-

From the above analysis it is found that the cost of voided slab is reduced considerably only if it is constructed in considerable large quantity and becomes slightly uneconomical when it is used with less quantity with less thickness. The voided slab has found economical, but due less thickness (150 mm) and less size of balls used there is less reduction in volume which ultimately results in slight uneconomical project, but it reduced weight considerably.

V. CONCLUSION

This innovative slab system with considerable reduction in self-weight and savings in materials combines all advantages of the other floor system, solving all problems caused by their disadvantages in the same time. Besides that the new floor system enhances the structural possibilities in combination with an improved cost-effectiveness. Further on the floor system gives a tremendous contribution to sustainable development.

The benefits of using plastic voided slabs, rather than solid slabs are greater for larger spans. Smaller spans do not require substantially thick slabs, therefore only small voids can be utilized and minimal savings are achieved. Larger spans are capable of using larger voids that greatly reduce the overall weight of the slab while meeting load capacity requirements.

- Deflection of bubble deck slab is found to be more than the solid slab
- Weight reduction is 4.7% compared to solid slab.
- Voided slab is economical when the slab construction is comparatively large and becomes uneconomical for very small construction.

REFERENCES

[1]. Dr. K. B. Parikh, "Parametric study of R.C.C. voided slab and flat plate slab SAP 2000", Vol 11, Issue 2, ISSN 2320-334
[2]. Martina Schnellenbach-Held and KarstenPfeffer, "Punching behavior of biaxial hollow slabs" Cement and Concrete Composites, Volume 24, Issue 6, Pages 551-556, December 2002.
[3]. Tina Lai "Structural behavior of bubble deck slab and their applications to lightweight bridge decks", M.Tech thesis, MIT, 2009.
[4]. A. M. Ibrahim, "Flexural capacities of reinforced concrete Two-way bubble deck slabs of plastic spherical voids" vol6, issue 2, ISSN 1999-8716, June 2013.
[5]. B. Vaignan and Dr. B. S. R. K. Prasad, "Analysis of voided deck slab and cellular deck slab using Midas civil", Vol 03, Issue 09, Sep-2014 ISSN 2278-0181.
[6]. B. G. Bhade, S. M. Barelikar, "An experimental study on two way bubble deck slab with spherical hollow balls", vol 7, issue 6, june 2016, ISSN 0976-3031.
[7]. Mr. Y. J. Purushottam, Mr. Y. H. Tambe, "Analytical study of solid flat slab and voided slab using ANSYS workbench",Vol 03, Issue 10, Oct 2016. ISSN 2395-0072.
[8]. A. K. Dwiwedi, Prof. H. J. Joshi, P. P. Mishra, M. Kadhane, B. Mohobey, "Voided slab design : Review Paper" vol 4, issue 1, ISSN 2321-2705, 2016.
[9]. M. M. Malviya, "Structural behavior of bubble deck slab and its applications : main paper",vol 4, issue 2, 2016 ISSN 2321-06