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Cost Analysis of Solid Slab and Voided Slab - A Review

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Abstract: ***A novel and inventive structural system for concrete slabs, called plastic voided slabs, has been developed. This system incorporates plastic voids within the reinforced concrete slab, resulting in a lighter self-weight for the structure without compromising its load-bearing capacity compared to a solid slab. This study aims to compare the design process of plastic voided slabs with that of reinforced concrete solid flat slabs. Specifically, the design of typical bays with identical thickness is analyzed to assess the differences between the two systems.***
Keywords: Load bearing capacity, Flat slab, Voided slab.

I. INTRODUCTION

The Bubble Deck slab is an innovative concrete floor system that has revolutionized construction practices. Utilizing recycled industrial plastic spheres, the Bubble Deck technology introduces air voids within the concrete while maintaining structural integrity through arch action. This ground breaking approach significantly reduces the overall weight of the slab by an impressive 35-40%, enabling the utilization of longer spans and minimizing the need for extensive supporting structures compared to conventional methods. As a result, the Bubble Deck offers numerous advantages over traditional concrete slabs, including cost savings, reduced material consumption, improved structural efficiency, shorter construction duration, and a sustainable, eco-friendly nature.

II. LITERATURE REVIEW

The some of the authors were studies on the various parameter of voided slab are as follows

1) *Jorgen Bruening (1990):* He studied that locks ellipsoids between the top and bottom reinforcement meshes, thereby creating a natural cell structure, acting like a solid slab. For the first time a hollow biaxial slab is created with the same capabilities as a solid slab, but with considerably less weight due to the elimination of superfluous concrete. Design of this type of the slab is based on the euro and the British codes.
2) *Neeraj Tiwari zafar (2013):* He had presented a paper. This presented a study on the Bubble Deck slab is a newly designed slab made by reinforcement mesh, hollow HDPE void, reinforcement mesh again at bottom. It is based on the patented integration technique there is the connection of steel and air. It is a hollow deck in which HDPE sphere void serve the purpose of reducing concrete that has no carrying effect.
3) *S.N. Bhagat et al. (2014):* States that, 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 carriedout and researchers suggest voided flat plate slab system to reduce the self-weight of the slab. In this study various parameters of the voided and solid flat plate slabs is calculated to compare the both systems. To evaluate the performance of the R.C.C voided and solid flat plate slabs, modeling of slabs is carried out using SAP 2000 having span ranging from 6x6 m to 14x14 m of 4x4 bay in both direction with thickness of the slabs 280 to 600 mm. The results drawn from the SAP 2000 are Reaction, Deflection, Moment and Reinforcement required for the voided and solid flat plate slabs.**Roberto Grade(2001):** He developed and patented a new system of hollow formers, in order to decrease the transportation costs (and CO2 production). The U- Boot formwork is a modular element made of re-cycled plastic for use in building lighter structures in reinforced concrete cast at the work-site. A truck of U-boot means approximately 5000m² of slab, once hollow formersare laid down at building site. The second innovation is the shape: U-boot creates a grid of orthogonal "I" beams, so the calculation of the reinforcement can be effected by any static engineer according to Eurocode, British standard or any local standard.The biggest advantage of U-boot is that it is stackable.

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4) *Schnellenbach-Held M., Ehmann S., P feffer K.(2009):* They wrote that Bubble deck slab is the slab in which some amount of the concrete is replaced by the plastic hollow bubbles which are made by the waste plastic material, which reduces the self-weight of the structure. The main effect of the plastic sphere is to reduce the dead load of the deck by1/3 in compare to solid slab having same thickness without effecting its deflection behaviour & bending.By applying the knowledge gathered during the behavioural analysis. Modular deck components for pedestrian bridges that is notably lighter but comparable in strength to typical reinforcement concrete section will be designed.

III. METHODOLOGY

A. *Benefits of Voided Slab*

1) Saves 30 to 50 % weight compared to a corresponding solid slab – equalstiffness.
2) 20% concrete reduction in other components.
3) The reduced weight of the slab will typical result in a change in design tolonger spans.
4) It is also seismic friendly as it lowers the total weight of the building.
5) Building costs are reduced by 8 to 10 %.

B. *Percentage Weight Reduction*

The significant weight savings were achieved by the plastic voided slab bays compared to the corresponding solid plate. The weight savings are expected since the majority of each plastic voided slab bay is composed of hollow voids. In addition to being lighter than solid slab bays of the same size, plastic voided slab bays can be lighter than solid slab bays that are smaller than the plastic voided slab bays.

To find out weight reduction of voided slab, first find out the volume of solidslab and volume of circle. Volume of solid slab is $Vs = l \times b \times h$ and $Vv = 4\pi r^3/3$ Where, b= Width of solid section surrounding a single sphere.

h=Total thickness of the slab

l=Total length of the slab

r= radius of circle

The percentage weight reduction of voided slab is calculated as

% Weight reduction = vol. of Sphere/ vol. of Solid section

C. *Cost Analysis for Solid Slab and Voided Slab*

In this section, we have done cost analysis for Solid slab and Voided slab to satisfy ourstudy objective. This study is at primary level so we have done rate analysis for cement, fine aggregate, coarse aggregate. Table No.4 shows the cost analysis for solid slab and Table No.5 shows cost analysis for voided slab. From both the tables of cost analysis we got to know amount required for solid slab is more than voided slab.

Rate Analysis

1) *Solid slab: M20*

Dry volume of concrete- 0.14m³
For wet volume increase weight volume by 52%
Wet volume of concrete=1.54 x 0.14 = 0.2156 m³
Cement = (1/(1+1.5+3)) x 0.2156 = 0.04312m³
No of bags = 0.04312/0.03472= 1.24~1.5 bag
Fine Aggregate = (1.5/(1+1.5+3)) x 0.2156 = 0.0588m³
Coarse Aggregate = (3/(1+1.5+3)) x 0.2156 = 0.1176m³

2) *Voided Slab: M20*

Dry volume of concrete = Vol. Of solid slab – Vol.of Sphere
$= 0.14-(9.05 \times 10^{-4}) \times 20 = 0.1219m^3$
For wet volume increase weight volume by 52%
Wet volume of concrete=1.54 x 0. 1219=0.1877m³
Cement = (1/(1+1.5+3)) x 0.1877 = 0.03412m³
No of bags = 0.03412/0.03472 = 0.98~1 bag
Fine Aggregate = (1.5/(5.5)) x 0.1877= 0.05119m³ Coarse Aggregate = (3/(5.5)) x 0.1877 = 0.1023m³

Table No.1Cost analysis for solid slab

Sr.No.	Parameters	Quantity (m^3)	Rate(Rs)	Amount(Rs)
1	Cement	0.04312	350/bag	434/-
2	Fine Aggregate	0.05881	2475/m^3	146/-
3	Coarse Aggregate	0.1176	1000/m^3	118/-

Table No.2 Cost analysis for voided slab

Sr.No.	Parameters	Quantity	Rate(Rs)	Amount(Rs)
1	Cement	0.03412 m^3	350/bag	343/-
2	Fine Aggregate	0.05119m^3	2475/m^3	127/-
3	Coarse Aggregate	0.1023 m^3	1000/m^3	102/-
4	HDPE voids	36 No's	2.5/-	90/-

IV. CONCLUSION

In this project, comparative study of voided slab and solid slab is performed with respect to % weight reduction and cost analysis. And we got variousresults with conclusions as follows.

1) By inserting the HDPE balls, unnecessary concrete is removed and self-weight of slab is also reduced, which results in the longer spans in voided slab system.

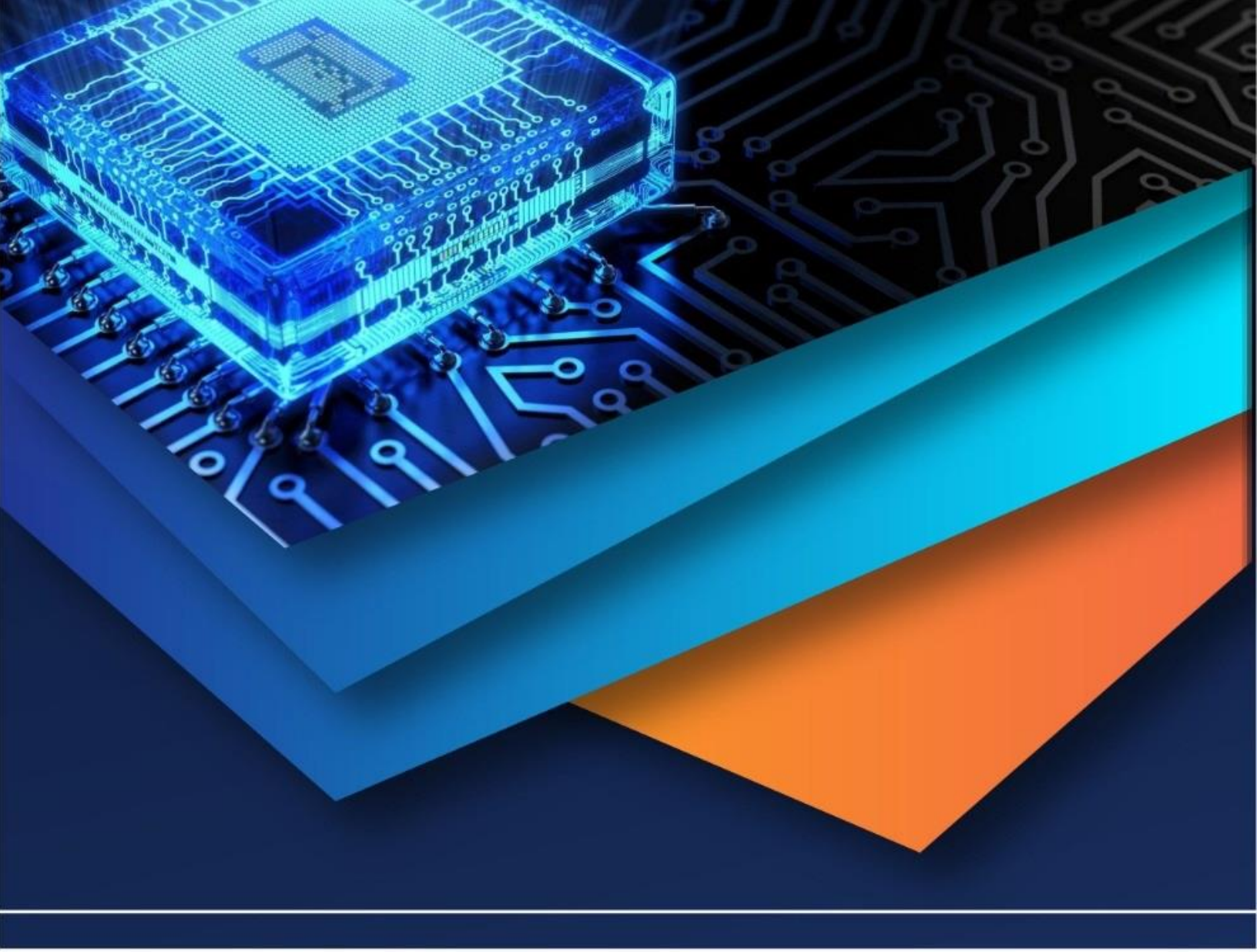
2) From the above study average % weight reduction is 0.73%. Reducing weight ofslabs can lead to a large reduction in overall seismic force, as weight is a leadingfactor in determining the seismic force.

3) From the cost analysis of Solid slab and voided slab, voided slab has reduced cost. So, we can conclude that overall structural cost of construction reduces.

HDPE balls are made up of recycled polypropylene and also its ability to save materialallows building to have smaller impact on the environment, all these aspects lead to a high degree of sustainability and an environment friendly design.

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