International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 04, April-2019

VOIDED REINFORCED CONCRETE SLABS: A STEP TOWARDS SUSTAINABLE DEVELOPMENT

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Abstract: The use of concrete as construction material has grown rapidly in the recent years. Apart from having many advantages over other construction materials, the major disadvantage of concrete lies in its production. Cement being the major constituent of concrete produces large amount of harmful and toxic gases during its manufacturing. A novel way to reduce the consumption of cement in concrete is by using the latest technology in slab construction, i.e. Voided slabs or Bubble Deck Slabs. The principle behind the use of voided slab is to eliminate the concrete which lies in the middle core of slab and place HDPE spheres in the slab. The stresses are zero along the neutral axis meaning the amount of stress in the concrete at the middle is negligible. The main advantage of adopting voided slabs is that it reduces the total dead weight of the structure drastically. As researches state that the weight of the slab reduces to about 35-40% as compared with the normal slab. Also the performance of the voided slabs can be further enhanced by using fibres along with HDPE spheres. This innovative slab system with considerable reduction in self-weight and savings in materials combines all advantages of the other floor systems, solving all problems caused by their disadvantages in the same time. This review discusses about the advancements of using voided slab system in construction practices.

Keywords –Concrete, Slab, Bubble deck, Voided Slab, Column, Foundation, Deflection, Hollow Slabs

I. INTRODUCTION

As we all know that now a day's pollution is one of the major factor which adversely affects our health & environment, many regions facing this problem & is increasing day by day. Construction work is also responsible for pollution as production of cement emits CO_2 near about 40kg/m^2, so taking these problems into consideration a new technique is develop i.e. BUBBLE DECK. Bubble deck is bi-axial hollow slab invented by Jorgen Bruenig in 1990's in Denmark. It is a technique of eliminating the ineffective concrete from neutral & placing the spherical balls. From the foregoing it was evident from tests conducted that though the bubble deck slabs were not as efficient as the conventional slabs, (having lesser load bearing capacity), they are very much satisfactory in slab construction considering the negligible difference in LBC (load bearing capacity) between them and the conventional. It is however interesting to see a weight reduction of 10.55% & 17% in the bubble deck slabs compared to the conventional slab (solid slab) which is an added advantage for the bubble deck slabs particularly in structures where load is an issue.

II. LITERATURE REVIEW

Ashraf Mir & Megha Gupta (2019) discussed about the benefits of rigid pavements utilizing bamboo fibre. The study investigated the feasibility of using bamboo as a fibre in pavement quality concrete with different water/powder ratios by adding bamboo fibre. This research presented the detailed amount of fibres used in the pavement quality concrete on trial basis. Since the strength and stiffness of natural fibre concrete reduces with time, adequate precautions should be taken when using natural fibre. To prevent the decay of fibres, the partial replacement of cement with mineral admixture is being recommended. Also using mineral admixtures makes concrete less permeable and less the permeability more durable the concrete is. Bamboo with high percentage of sugars(4.92%) having retarding effect on the setting and strength development of cement matrix should be kept in concentration and to overcome that, addition of chemical admixtures is necessary to counteract the adverse effect.

Mustafa (2017) did the experimental investigation on flexural behaviour of continuous bubbled reinforced Reactive Powder Concrete (RPC) flat slabs, such as the ultimate load carrying capacity, deflection and crack pattern of slab at the ultimate load, seven types of slabs were tested. The parameters of the experiment were type of concrete (RPC and Normal Concrete (NC)), bubbles diameter to slab thickness ratio (D/t) of (0.6 and 0.7), type of loading (distributed and line load) and solid slab. They concluded that

1. The UL(ultimate load) and the maximum deflection depends on (D/t) ratio due to decrease in self weight of slabs, by increasing (D/t) the ultimate load increased up to (16.52%) and the maximum deflection decreased up to (6.89%).
2. The stiffness of the bubbled slab is less than solid slab, but the reduction in self weight for bubbled slab seems to reduce the difference in stiffness when the load is increased but at the end the solid slab increases both ultimate load and maximum deflection by about (4.05%) and (23.5%), respectively.

3. Test results shown that by using RPC compare to NC the ultimate load along with maximum deflection increased tremendously up to about (108.9%) and (37%), respectively.
4. By changing the type of loading from distributed to line load, the slabs experienced more concentrated pressure due to less applied point loads and that causes the drop in ultimate load value up to (5.16%), since the bubbled slabs strength in shear is less than their flexural strength. But the three pointed load make the slabs to have more deflection up to (12.11%) due to concentration of applied load on centre slabs.
5. Crack pattern of the slabs tells that all slab with (D/t =0.7) and solid slab had
flexural failure mode while the slabs with (D/t = 0.6) along with flexural failure experienced shear failure at slabs edges and slab's centre for slab subjected to line
load.

Binu P (2016) did a numerical study on Bubble Deck Slab with the help of software i.e. ANSYS, basically in this research the GFRP stirrups were used & shear strength of bubble deck slab were checked & comparison were made by solid slab. Fe415 steel were used & diameter of ball were 180mm & GFRP of length 2100mm, width 200mm, thickness 2mm used. If both were compared i.e. solid slab & bubble deck slab, it was seen that punching shear capacity of bubble deck slab is less. Bubble deck can accomplish only 70 % load carrying capacity. But due to the strengthen bubble deck slab with GFRP strips improve load carrying capacity up to 20 % & finally the conclusion is made that Punching shear capacity of bubble deck slab is a significant problem because of its less weight. GFRP strengthening system is used in this study. Strengthened slabs have higher punching capacity compared with bubble deck slab. Increment in load carrying capacity up to 20 % due to strengthening of bubble deck slab with GFRP. Strengthened bubble deck has low deflection compared to unstrengthened bubble deck slab. 8 % of global carbon dioxide is due to cement production. One ton of cement causes emission of about 800 kg of CO_2 (carbon dioxide). One m3 of concrete causes CO_2 (carbon dioxide) emission close to 300 kg. Introducing HDPE balls of 180 mm diameter in to a flat slab of thickness 230 mm we can save the weight near about 23.62 % around one ball. Bubble deck slab have reduces the concrete usage in which 1 kg of HDPE balls replace more than 100 kg of concrete

Er. Immanuel Joseph Chacko, et al (2016) did the experimental investigation on voided slab by using the ball of diameter 60mm (S60) & 65mm(S65) further load vs deflection, strain & load capacity test were performed & concluded that the load vs. deflection of S60 showed positive result comparing to solid slab and S65, Strain characteristic were same that of solid slab. S60 is preferred as a suitable Bubble Deck slab

Luong Van Hai & Tran Minh Thi (2013) did the experimental analysis of Bubble-Deck slab using modified elliptical balls, in this experiment hollow spherical balls with diameter 186mm and hollow elliptical balls with diameter 240mm and height 180mm were taken & the slab of dimension 1900x800x230mm. By using the modified Bubble Deck with hollow elliptical balls 240-180mm, the loading capacity is increased from 6% to 11% as compare to that of traditional Bubble Deck with hollow spherical balls 186mm. In addition, the experimental results also show that the modified Bubble Deck with hollow elliptical balls 240-180mm has better shearing capacity as compare to the Bubble Deck with hollow. Spherical balls 186mm. Finally, it can be concluded that by using the hollow elliptical balls, the better load-bearing capacity can be achieved in bubble deck. Therefore, the Bubble Deck presents the promising future of advanced structure engineering and it could be applied effectively in the construction works.

Amer Ibrahim, et al (2013) successfully done the experimental study on Load capacity, crack pattern & compressive strain & finally concluded that the concrete compressive strain of Bubble Deck specimens is greater than that of a solid slab. Deflections of Bubble Deck specimens were a little higher than that of a solid slab. The concrete compressive strain of Bubble Deck specimens is greater than that of a solid specimen.

Kumar (2012) performed finite-element analysis of Bubble Deck slab systems using SAP 2000 and compared the void slab system with solid slabs. This study showed that bending stress, deflections, and shear resistance are marginally somehow differ than those for solid-slab systems, in the range of 5–7%, with a slab-weight decrement of 35%.

Marais et al. (2010) did the investigation i.e. the economical value of Bubble deck slabs in South Africa and comparison were made in the construction cost of two other large span slab systems, namely coffer and post-tensioned slabs. Conclusion were come out, that the stiffness of SVF slab areas should be reduced by approximately 10% compared to that a solid slab with same thickness.

Sergiu Calin , et al (2009) conducted the investigation on various parameters like cost price, Bending Strength and Deflection Behaviour , shear strength etc & finally concluded that Bubble Deck will distribute the forces in a better way (an absolute optimum) than any of the other hollow floor structures. Because of the 3-D structure and the gentle graduated force flow the hollow areas will have no negative influence and cause no loss of strength Furthermore, the practical experience shows a better effect in the process of concreting.

Tae-Young Jang & Sang-Mo Kim (2009), did the comparative study between flat slab & Bubble deck slab & practically it shows that bending strengths of all the bending specimens were larger than the ultimate bending strength

and the shear strengths of all the shear specimens were larger than 60 percent of the shear strength. In order to increase the shear strength capacity and bending moment in the areas with stress concentration (E.g. near the columns or walls) it is possible that plastic balls as void former is uninstalled. Due to advantage of dead weight reduction of floor slabs, TVS system is more structural safety and economic than flat plate system & it is also verified via software that Bubble deck slab gives better result in Earthquake because of dead load of deck & it is eco-friendly too.
Finally, conclusion were made that TVS system, new eco-friendly slab system, has the structural, economic, and environmental effects compared with existing general floor slabs during the total life cycle of buildings. Also TVS system can be a potent alternative for sustainable nature, and symbiosis between human and nature beyond green and ecological building. We have to try to develop green technologies to minimize environmental impacts by improving the eco-friendly technologies in field of construction work of buildings

Gudmundur B, (2003) studied on the Bubble Deck based upon, the way of linking air and steel The Bubble Deck is a two-way hollow slab in which HDPE balls serves the purpose of eliminating the concrete that has no carrying effect, by adopting the geometry of the ball and the mesh width, an optimized concrete construction is obtained, with simultaneous maximum utility of both moment and shear zones. And finally concluded that the essential effect of the bubbles in the weight reduction of the deck. Results also show the dead load of the Bubble Deck to be 1/3 lesser than a solid deck with the same thickness – and that without any effect on the bending strength and the deflection behaviour of the deck.

III. CONCLUSIONS

Based on the study done, it can be concluded that Bubble deck slab is far better than solid slab as it can reduced the weight of slab because of reduce weight in slab more floors can be added on same height of building , larger spans can be achieved, fewer columns ,construction can be more faster & easily, cost of construction can be reduced (Cheaper), 1 kg of plastic saves 100kg of concrete , strain is less ,therefore by adopting this technique building can be built sustainable & Eco- friendly.

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