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Experimental Study on Bubble Deck Beam Using HDPE Balls

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Abstract: In building constructions, the beam is a very important structural member to carry load of the slab. Bubble beam is a method of virtually eliminating all concrete from the middle of a Beam, which is not performing any structural function, thereby dramatically reducing structural dead load. Bubble beam is a beam whose core is replace with Spherical balls that can be of various sizes and shapes. Usually the Bubble Deck system combines the benefits of factory manufactured elements in controlled conditions along with on-site completion. Some of its major benefits are lower total cost, reduced material use, enhanced structural efficiency, decreased construction time, and is a green technology. In this project the in-effective concrete in the Centre of the beam is replaced with High density polyethylene hollow spheres, using M30 grade of concrete no of beams with and without spherical bubbles were casted to compare weight and flexural strength.
Keywords: Conventional Beam, Bubbled Beam, Concrete, etc.

I. INTRODUCTION

The elements of beam design is a topic of great interest for structural engineers and contractors. Beam design is integral in the design and construction of a structure. Most structural beams are comprised of wood, steel or concrete. Each of these construction materials reacts differently under the stress of a load. Each also has its own unique advantages. Concrete beams are most often seen in commercial construction, such as in the erection of multi-level parking decks, hospitals, and large hotels. Concrete beams are also commonly used as bridge and highway supports. Some concrete beams are used in conjunction with steel beams to provide added strength.

Concrete is a strong building material, but it is susceptible to water damage and cracking. Iron bars are often included in the beams to add strength and stability over areas prone to greater stress. Concrete beams area also desirable for their ability to absorb sound and vibration. Nowadays research efforts are continuously looking for new, better and efficient construction material and method. The concrete should be used as efficiently as much as possible.

Concrete materials are still a dominant material for construction due to its advantages such as workability, low cost and fire resistance as well as its low maintenance cost. It is formed from a hardened mixture of cement, fine aggregate, coarse aggregate, water and some admixture. Massive exploration of the natural resources for producing concrete affect to the environment condition and global warning. We have responsibility to reduce the effect of the application of concrete materials to environmental impact. The concrete should be used as efficient as possible.

According to the natural behaviour of the concrete, it is strong in compression and weak in tension. Our assumption to design the R.C beams is the contribution of tensile stress of the concrete is neglected. The flexural capacity (MR) of the beam is influenced only by compression stresses of the concrete and the tensile stress of the steel reinforcement. Efficient use the concrete materials canbe done by replacing the concrete in and near the neutral axis.

II. BUBBLE-DECK TECHNOLOGY

Bubble-Deck is a biaxial technology that increases span length and makes the depth of beams thinner by reducing the self- weight while maintaining the performance of reinforced concrete beam.

Bubble deck system is a new construction technology using recycled spherical balls in slabs to reduce self-weight of the structure as part of the concrete is replaced by the bubbles. The use of this spherical balls/bubbles to fill the voids in the middle of abeam eliminates 35% of beam self- weight compared to solid slab having same depth without affecting its deflection behavior & bending strength of beams.

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III. OBJECTIVES OF PAPER

1) To estimate saved amount of concrete as spherical balls introduced in the core of the beam.
2) To determine the flexural strength and shear strength of beam and compared with conventional beam
3) To study the bending (deflection) behaviour of conventional beam and bubble deck beam.
4) To determine load carrying capacity ofbubbled deck beam and compared with conventional beam.

IV. LITERATURE REVIEW

1) Behavioral Analysis of Conventional Slab and Bubble Deck Slab under various Support and Loading Conditions using ANSYS Workbench by Sameer Ali, Mr. ManojKumar. The objective of this study was to perform the behavioral analysis of conventional slab and bubble deck slab using ANSYS workbench 14.0. This comparative studyincludes the study of normal slab and slab with HDPE spherical ball at Centre to form voids. This paper presented a brief overall review on the conventionalslab suitability and bubble deck slab suitability at different places as a different component (office slab, bridge deck slab etc.).Office slab test provides the results of prior research, proving that the Bubble Deck slab performed better than a traditional solid concrete, biaxial slab. The maximum stresses and internal forces in the voided deck about to 40% less than the solid slab due to the decreased dead load from the use of HDPE spheres in place of concrete. The deflection of the Bubble Deck slab was slightly higher but the stiffness decreased due to the presence of the bubbles but this situation will be overcome by the reduced overall stress in the slab. This paper demonstrated that this type of biaxial deck will give better results under long-termanda more durable floor slab under a dominant gravity and uniformload.

2) Structural Behavior of Bubble Deck Slab by P. Prabhu Teja, P.Vijay Kumar, S.Anusha, CH.Mounika, Purnachandra Saha. In this paper they have checked the properties of bubble deck slab like flexural strength, shear strength, durability, deflection, sound insulation, vibration, fire resistance etc. using finite element analysis. They observed that deformations developed in the solid slab werecomparatively less than bubble deck slab. They have concluded from this paper that bending stresses in the bubble deck slab were found to be 6.43% lesser than that of a solid slab, deflection of bubble deck was 5.88% more than the solid slab as the stiffness was reduced due to hollow portion, weight reduction was 35% compared to solid slab, Shear resistance of bubble deck slab was 0.6 times the shear resistance of the solidslab of same thickness.

3) Effect of Reinforced Concrete Beam with Hollow Neutral Axis by Jain Joy & Rajesh Rajeev. The objective of the investigation is to develop a Reinforced Concrete Beam with hollow neutral axis which may replace the position of reinforced concrete beam in near future. However, in RC beams strength of concrete lying in and near the neutral axis is not fully utilized. So this un- utilized concrete is removed by replacing with any light-weight material. The material incorporated in the concrete beam is PVC pipe, which occupy the concrete volume in the neutral axis, where the compressionand tension is zero thereby making the beam hollow. Theproperties of PVC isnot been used since it is used only as a filler material in concrete. Specimens of solid RC beams and Hollow RC beams are cast and tested for four pointflexure. Then the results are compared and the effects are studied. The self-weight of this developed RC beams are expected to be reduced with the decrease in concrete volume hence proving the beams to be economical. Experimental validation is carriedout analytically with ANSYS 12.1software.

4) Experimental study on bubble deck slab by Mr. Muhammad Shafiq Mushfiq, Asst. Prof. Shikha Saini and Asst. Prof. Nishant Rajori. Objectives of this paper was To determine the load bearing capacity of bubble deck slab and compare with conventional slab with different B/H ratio and to estimate the amount of concrete saved as a result of spherical balls introduction into the core of the slab. From the foregoing it was evident from tests conducted that though the bubble deck slabs were not as efficient as the conventional slab, (having lesser load bearing capacity), they are very much satisfactory in slab construction considering the negligible difference in load bearing capacity between them and the conventional. It is however interesting to note a weight reduction of 10.55% & 17% in the bubble deck slabs compared to the conventional slab which was an added advantage for the bubble deck slabs especially in structures where load is anissue.

V. MATERIALS USED & METHODS ADOPTED.

A. Portland PozzolanaCement (PPC)

Itis a variation of OPCwhich includes a mixture of a pozzolanic material which is known to increase the strength of concrete and reduce theamount of OPC used. Now a days it is being used as a replacement to OPC as it is known to fulfil green building criteria and hence helps in sustainable development.
Note: We have used Ultratech Cement (The Engineer's Choice) of M 30 grade.

B. Fine Aggregates

We used Natural River sand size 4.75mmand below confirming to zone 3 of IS 383-1970 is being usedas the fine aggregate.

C. Coarse Aggregates

We used Natural crushed stone of size between 20mm to 40 mm. Note: We used 20 mm size Angular Coarse Aggregate.

D. Hollow Plastic Spherical Bubbles

The hollow plastic spherical bubbles used in this project are manufactured from recycled plastic of diameter 60 mm. The purpose of usingrecycled material is to curb consumption of finite natural resources such as oil and minimize the burden on the environment through the cyclical use of resources, therefore the recycling martial reduces inputs of new resources and limits the burden on the environment and reduces the risks to human health.

E. Water

Water is the key ingredient, which when mixed withcement, forms a paste that binds the aggregate together. The water causes the hardening of concrete through a process called hydration. The role of water is important because the water to cement ratio is the mostcritical factor in the production of "perfect" concrete. PH value of water used for concreting should be greater than 6 and should be potable.

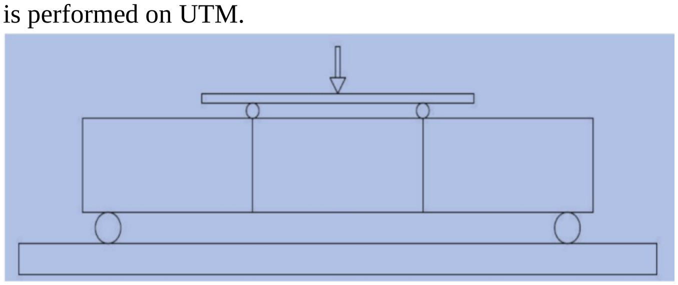
F. Steel Reinforcement

Steel is an alloyof iron and carbon and other elements. High grade steel of Fe 500 is generally used. The same grade of steel is used in both in top and bottom steel reinforcement. We used Fe 500 steel & 12 mm diameter steel bar for main reinforcement and distribution reinforcement.

Reinforced Steel of 3-12mm bars for main steel & 5-8mm bars for stirrups @ 175 mm c-c spacing and spherical bubbles(HDPE) of 60 mm dia. are reinforced in Beam Mould of size 75cm x 15cm x 15cm.

VI. EXPERIMENTAL TESTS RESULTS

1) Flexure Test: Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. It is performed on UTM.



Two Point Loading

2) Calculation for flexural Strength

a) For Conventional Beam 1 :- Flexural Strength = Load/Area

= 78.4 x 10^3/22500

= 3.484 N/mm^2

b) For Bubbled Beam 1 :- Flexural Strength = Load/Area

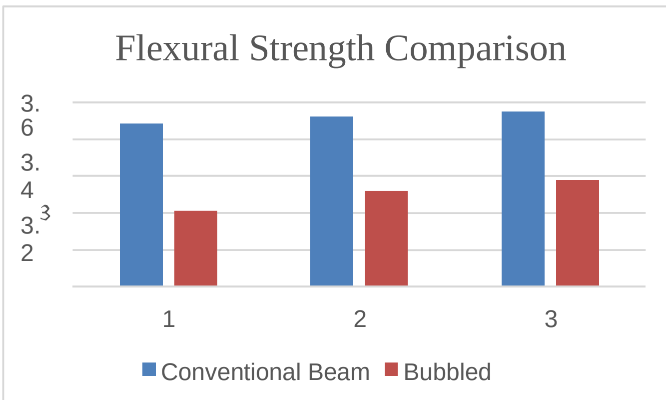
= 67.80 x 10^3/22500

= 3.013 N/mm^2

No. of Beam casted for test	Age of concrete (Days)	Load at Peak (KN)		Flexure strength (N/mm^2)	
		CB	BB	CB	BB
1	28	78.4	67.80	3.484	3.013
1	28	79.2	70.2	3.52	3.12
1	28	79.9	71.5	3.551	3.177

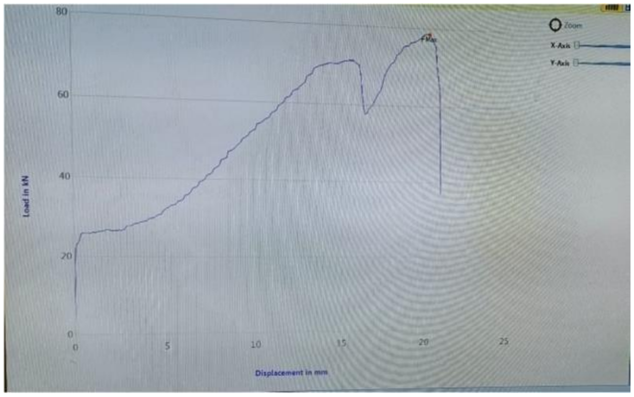
Table.1. Flexure Strength Test.

As per the test results observe in that all bubble beam and conventional beam shows the nearly same deflection at particular load.



VII. COMPARISION OF COMPRESSIVE STRENGTH OFCONCRETE

In total we have casted 6 beams and tested, as per the test results observed, all bubbled plastic and bubbled rubber cube and conventional cube shows the nearly samestrength at particular load but as compared to bubbled plastic cube the strength of bubbled rubber cube is more due to its solid in nature. As plastic bubbles are hollow they do not bear more Compressive strength, as soon as the loading acts they fail earlier than rubber bubbles.



VIII. ESTIMATION OF SAVED AMOUNT OF CONCRETE

Concrete is mixture of cement, sand, aggregate and water. The amount of concrete directly affect the cost of project hence it is necessary to reduce the amount of concrete to reduce the cost of the project. And due to its higher density, weight of the structural members also increases.

Volume of Beam (V_1) = 0.75m x 0.15m x 0.15m

= 0.016875 m^3

Volume of HDPE Balls = 4/3 x 3.14 x 0.030^3 x 8(nos.)

= 9.0432×10^{-4} m^3

% Reduction of concrete = v2/v1

= $9.0432 \times 10^{-4}/0.016875$

= **5.35 %**

Avg. weight of conventional Beam(w1)= 43.46 kg Avg. weight of bubbled beam(w2)= 40.1 kg

% Reduction of weight = 100-(w2/w1) x 100

=**7.73 %**

Comparison between load carrying capacity :- Load on conventional Beam = 79.16 KN Load on Bubbled Beam = 69.83 KN Conventional Beam carry 13% more than Bubbled Beam.

IX. RECOMMENDATION FOR USE AND FUTURE SCOPE

A. *Recommendation For Use*

1) Used for construction all type of building, Especially single storey & each and every Roof Floor.

2) Best of lager span halls like Theatres and Auditorium.

3) Used in Parking areas.

B. *Future Scope*

1) In future we can extend the study for behaviour of Bubbled beam at beam-column junctions.

2) As bubbled beam lacking in strength further study can be made on improving strength of the same.

X. RESULT

A. Conventional Beam carry 13 % more load than bubbled Beam.

B. Reduction of concrete 5.35 % as compared to Conventional beam.

C. Reduction of weight 7.73 % as compared to Conventional Beam.

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