Comparative Study of Bubbled Beam and Conventional Beam

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Abstract— Now days there is need of better and efficient construction material and method. We have the responsibility to reduce the effect of application of concrete material to environmental effect. In building constructions, the beam is a very important structural member to carry load of the slab. Objective of this paper is to develop a bubbled beam by placing high density polyethylene balls below the neutral axis .reasons to use high density polyethylene balls are light weight, high strength to weight ratio, Non-reactive with other material. By introducing HDPE balls leads to a 5-10% of lighter beams which reduces loads on columns, walls and foundation and of course on entire building. The region below the neutral is in tension and above the neutral axis is in compression. Concrete is weak in tension & strong in compression hence concrete below the neutral axis is not performing any structural function. Specimen of conventional beam and bubbled beam are cast and tested for two point load. Then the results are compare and effects are studied. Self-weight of this developed beams are expected to be reduced with decrease in volume. Hence proving the beams to be economical. Stress-strain behaviour of conventional beam and bubbled beam is observed by application of strain gauges and recorded by strain meter. The various parameters like self-weight ,flexural strength, stress strain behaviour, deflection ,crack pattern are calculated to compare both the specimens and estimation of amount of concrete saved by bubbled beam as compared to conventional beam is calculated. This bubbled beam will be effective for longer span.

Key words: Neutral Axis, Bubbled Beam, Light-Weight Material, Flexural behaviour, Stress-Strain Behaviour

I. Introduction

A Beam is a structure loaded by forces acting transversely to its length and this make the beam bend. These loads resist by the beam laterally to t.he axis of the beam.

Bubbled beam is a structure in which concrete below the neutral axis which is not performing any structural function is replaced by high density polyethylene balls (HDPE).reason to use HDPE balls are:

1) Light weight.
2) Resistance to many different solvents and chemicals.
3) Easily withstand higher temperature.
4) Strength to density ratio is high.

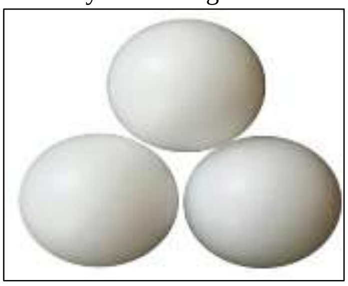

Fig .1: HDPE Balls

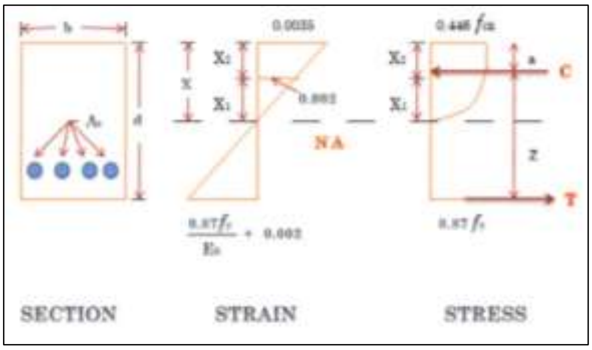

Fig. 2: Stress-Strain Behaviour

II. Experimental work consist of

1) Comparison between conventional beam and bubble beam with respect to various parameters like weight, load at first crack, load at failure.
2) Stress strain behaviour.

III. Objective of the work

1) To determine the amount of concrete saved by the HDPE balls below the neutral axis.
2) To determine stress-strain behaviour of bubbled beam in comparison with conventional beam.
3) To determine the flexural strength and shear strength of beam and compare with conventional beam.

IV. Methodology

The methodology of the work consist of:

1) Selection of grade of concrete; M35.
2) Mix design of M35 grade of concrete.
3) Casting of conventional beam and bubble beam.
4) Application of strain gauges to determine strain.
5) Conducting two point load test using UTM.
6) Study the effect and documentation.

V. Mix design

MATERIALS	QUANTITY (kg/m^3)	Specific gravity
Cement	440	
Fine Aggregate	841	2.84
Coarse Aggregate	1118	2.8
Water	155	1
Water cement ratio	0.35	

Table 1: Mix design

VI. Experimental investigation

Casting and testing of specimen consist of 6 beam specimen of size 150*150*700mm out of which three conventional and three bubbled beam.

Fig. 3: Specimen of Beam

6 strain gauges used along length of the beam with gauge length 60mm. The beam designed as under reinforced section according to IS 456-2000.It is reinforced with 8mm dia. at bottom and top. Minimum shear reinforcement provided @175mm c/c. All the beam specimens were subjected to a four point loading test.

The depth of neutral axis is calculated by considering M35 grade concrete and Fe415 steel with an effective cover of 20 mm.

Actual depth of neutral axis (X_u)

= 0.87 fy x Ast/0.36 f_{ck} x b

= 0.87 x 415 x 3 x 50.27/0.36 x 35 x 150

= 28.81 mm

Depth of limiting neutral axis (X_{ulim}) = 0.479 x d

= 59.9mm

$X_u < X_{ulim}$ ….Under reinforced section

A. *Size of HDPE balls*

Depth of limiting neutral axis = 60mm

Depth below the neutral axis=150-90 = 90mm

Provide the cover of 20mm

Size of ball=90-20(cover) = 70mm

So provide size of ball 60mm.

B. *Minimum shear reinforcement*

ASV/ (b*Sv) = 0.4/ (0.87*FY) Svprov

= 175mm

8mm Φ bar @ 150 mm spacing

In the zone below neutral axis a cage of wire is provided for placing the balls and to maintain the fixed position of the ball along the length of beam.

VII. TEST PROCEDURE

Flexural strength of specimen is determined using two point load test, behaviour of beam is kindly observed from beginning to failure. The loading was stopped when the beam is on the verge of failure. The value of the load at the first and ultimate crack propagation are observed and also the value of the load applied and deflection are noted further plot of load verses deflection. Digital strain meter is used to give readings, strain gauges are used to determine strain at centre which are applies along length of the beam.

Fig .4: Digital Strain meter

VIII. EXPERIMENTAL RESULT AND DISCUSSION

A. *Load carrying capacity*

Two point load test is conducted to determine ultimate strength of the beams.it was found that all load carrying capacity of bubbled beam is less than conventional beam.

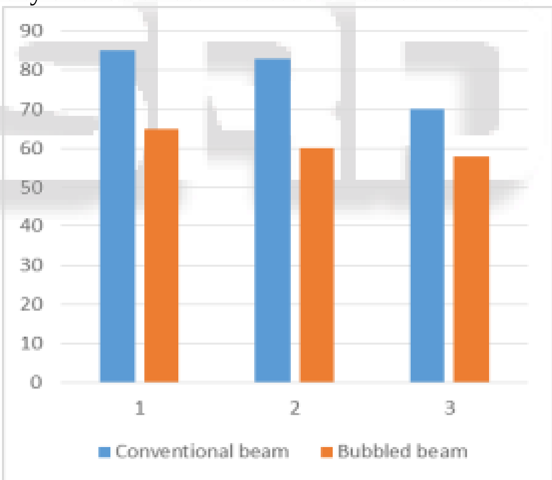

Chart 1: Load at first crack

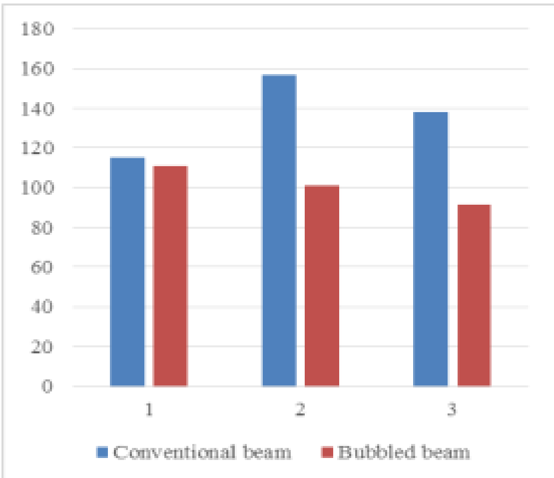

Chart 2: Load at failure

B. Load v/s deflection

As we know the load is directly proportional to the deflection. The load at particular deflection of conventional and bubbled beam are safe up to 95kN.

As per the test results observe in that all bubble beam and conventional beam shows the same deflection at particular load. In engineering, deflection is the degree to which a structural element is displaced under a load. It may refer to an angle or a distance.

The deflection distance of a member under a load is directly related to the slope of the deflected shape of the member under that load, and can be calculated by integrating the function that mathematically describes the slope of the member under that load.

LOAD	C1	C2	C3	B1	B2	B3
0	0	0	0	0	0	0
5	0	0	0	0	0	0
10	0	0	0	0	0	0
15	0.28	0	1.2	0.34	0	0.73
20	0.77	0	1.5	0.75	0	1.24
25	1.28	0.01	1.96	1.26	0.01	1.38
30	1.52	0.05	2.15	1.45	0.16	1.5
35	1.67	0.18	2.27	1.67	0.32	1.59
40	1.84	0.34	2.45	1.83	0.47	1.68
45	2.11	0.49	2.61	2.01	0.61	1.79
50	2.41	0.66	2.8	2.15	0.82	2.03
55	2.61	0.9	2.97	2.26	1.01	2.24
60	2.82	1.08	3.16	2.39	1.22	2.46
65	3.05	1.24	3.35	2.56	1.62	2.79
70	3.29	1.42	3.59	2.76	1.86	3.12
75	3.57	1.56	3.89	2.96	2.08	3.52
80	3.87	1.76	4.06	3.19	2.28	3.9
85	4.19	1.97	4.26	3.42	2.58	4.32
90	5.85	2.23	4.45	3.69	3.03	4.8
95	6.72	2.43	4.69	3.95	3.65	-
100	7.2	2.7	4.95	4.22	4.31	-
105	7.59	2.98	5.25	4.68	-	-
110	8.22	3.25	5.46	5.16	-	-
115	9.37	3.6	5.93	-	-	-
120	-	3.9	6.33	-	-	-
125	-	4.23	6.75	-	-	-
130	-	4.7	7.26	-	-	-
135	-	5.37	8.12	-	-	-
140	-	6.13	-	-	-	-
145	-	7.08	-	-	-	-
150	-	8.37	-	-	-	-
155	-	10.02	-	-	-	-

Table 2: Deflection at specific load

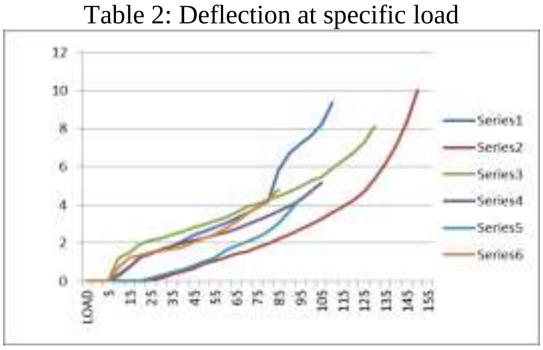

Chart 3: Load vs. deflection

C. Crack pattern

It is clear from all beams that bubbled beam cracked at lower loads than conventional beam. The difference in the load is about 15KN.this indicates that concrete part in conventional beam participates in increasing the cracking load to some extent only that is concrete in neutral axis do not play significant role in increasing cracking load. The crack pattern of bubbled and conventional are as shown in fig.

Fig 5: Crack Pattern

D. 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 reduced amount of concrete to reduce the cost of project. And due to its higher density, weight of the members also increases.

Volume of beam = 0.15*0.15*0.7

V_1 =0.01575m^3

Volume HDPE Balls V_2 =No. of balls *4/3 *3.14*r^3

=8*4*3.14*/3*(0.0653/2)

=1.15*10^{-3}

%reduction of concrete = v_2/v_1

=1.15*10-3/0.01575

=7.3%

Average weight of conventional beam (w1) =42.08

Average weight of bubbled beam (w2) =39.4

%reduction of weight=100-(w2/w1)*100

=6.37%

E. Stress-Strain Behaviour

The relationship between the stress and strain that a particular material displays is known as that particular material`s stress-strain curve.it is unique for each material is found by recording the amount of deformation (strain).

Fig. 6: Fixing of strain gauge

At particular load strain behaviour of conventional and bubbled beam is same. Behaviour of strain of bubbled and conventional as shown in graph.

In table, C indicates conventional beam & B indicates bubbled beam.

Stress	Strain C1	Strain C2	Strain B1	Strain B2
0.22	2	3	3	34
0.44	11	2	5	127
0.66	30	20	6	273
0.89	38	50	7	409
1.11	232	104	18	557
1.33	874	133	26	686
1.55	1263	173	55	916
1.77	1538	267	83	1290
2	1732	341	126	1630
2.22	1899	470	600	1906
2.44	2069	625	1353	2264
2.67	2280	963	1745	2593
2.89	2491	1211	2250	2965
3.11	2664	1604	2627	3407
3.33	2804	1900	3050	3948
3.55	3104	2581	3484	4464
3.78	3336	2929	3774	4398
4	3757	3186	4203	-
4.22	4109	3479	4659	-
4.44	4553	3874	5081	-
4.67	4990	4671	5229	-
4.89	5590	5360	-	-

Table 2: Stress-Strain value

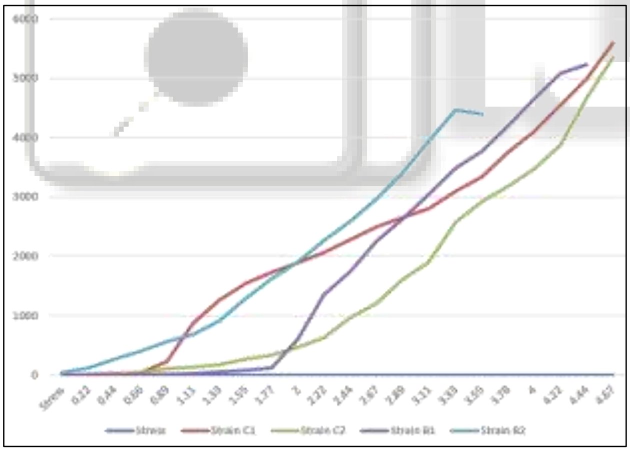

Chart 4: Stress vs. Strain

IX. Conclusion

1) Weight of bubbled beam is 6.37% less than conventional beam.
2) Stress-strain behaviour at particular load is same for both bubbled and conventional beam.

X. Future Scope

1) In future we can extend the study for Behaviour of bubbled beam at beam-column junctions.
2) From results we found that bubbled beam lacking in strength so further study can be made on strength improvement of the bubbled beam by providing shear reinforcement.