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COMPARATIVE STUDY ON STRENGTH OF RC BEAM USING GEOPOLYMER CONCRETE AND ADOPTING BUBBLE TECHNOLOGY

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ABSTRACT—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 M20 grade of concrete no of beams with and without spherical bubbles were casted to compare weight and flexural strength.

Keywords:
Bubble technology, Geopolymer concrete, Ordinary Portland Cement Concrete, Sodium hydroxide, GGBS,Glasspowder

I. INTRODUCTION

1.1.Genral

The Bubble Deck technology developed in Europe makes use of high-density polyethylene hollow spheres to replace the ineffective concrete in the centre of the slab, thus decreasing the dead weight and increasing the efficiency of the floor. This method is used in the concrete floor system. Concrete is good in compression and hence is more useful in the compression region than in the tension region. The reduction in concrete can be done by replacing the tension zone concrete. Keeping the same idea in mind, an attempt has been made to find out the effectiveness of plastic bubbles by replacing concrete in the tension zone of Ordinary Portland Cement Concrete (OPCC) and Geopolymer Concrete (GPC) beam.

1.2GEOPOLYMER CONCRETE

Geopolymer Concrete does not form calcium-silicate-hydrates (CSHs) for matrix formation and strength like OPCC but utilizes the poly condensation of silica and alumina precursors to attain structural strength. In this project, M20 concrete mix is used to prepare both OPCC and GPC beams. The trial mix is tested for compressive strength. Flexure test is done is done for 28 days of curing of the beams. The procedure is repeated for beam samples with bubble mesh and bubble mesh along with shear reinforcement. Comparative analysis of the OPCC and GPC beams are done to observe the percentage reduction in self-weight and cost effectiveness. Analysis of behavior of GPC beam in comparison with that of OPCC beam. A beam is a structural element that primarily resists loads applied laterally to the beam's axis. Its mode of deflection is primarily by bending. The loads applied to the beam result in reaction forces at the beam's support points. The total effect of all the forces acting on the beam is to produce shear forces and bending moments within the beam, that in turn induce internal stresses, strains and deflections of the beam. Beams are characterized by their manner of support, profile (cross-section), length, and their material. Beams classified on basis of support are simply supported, fixed, overhanging, continuous, cantilever etc.

1.3. BUBBLE-DECK TECHNOLOGY

Bubble-deck technology Bubble-Deck is a biaxial technology that increases span length and makes the depth of beams thinner by reducing the selfweight while maintaining the performance of reinforced concrete beam. Bubble deck system is a new construction technology using recycled spherical balls in slabs to reduceself-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 a beam eliminates 35% of beam self weight compared to solid slab having same depth without affecting its deflection behavior & bending strength of beams.

II.OBJECTIVES

•To compare and analyse the behaviour of geopolymer concrete adopting Bubble Technology (GPC) beam with that of Ordinary Portland Cement Concrete(OPCC) beam.
•To analyse the behaviour of geopolymer concrete beam by replacement of tension zone concrete with non-conventional materials like plastic balls
•Cost effective analysis by partial replacement of tension zone concrete in beam by the plastic balls. To determine the load bearing capacity of bubble deck beam and compare with conventional beam.
•To estimate the amount of concrete saved as a result of inducing spherical bubbles into the core of the beam.

III.ADVANTAGES OF BUBBLE TECHNOLOGY

•Superior Statics. Bubble deck Beam has a superiority over the conventional Beam as it has reduced weight ,increased strength,
• Production and Carrying Out is simple.
• Easily Transportation
• Economic Savings
• Consideration of Safety is more as compare to the conventional beam
• Environmental Improvement
• Explosions Safe.
• Saving in concrete is about 15% by weight
• It is observed that the placement of bubble mesh in concrete beam not require any additional time

IV LITERATURE REVIEW

4.1P. K. Jamdade and U. R. Kawade: studied the strength of Geopolymer concrete by using oven curing. In this study Geopolymer concrete is prepared by mixing sodium silicate and sodium hydroxide with processed fly ash. The concrete is cured at different condition and different temperatures i.e; 600 C, 900 C and 1200 C so as to increase the strength of concrete. It was observed that higher curing temperature resulted in larger compressive strength of Geopolymer concrete, evethough an increase in the curing temperature beyond 600 C did not increase the compressive strength substantially. Also longer curing time improved the polymerization process resulting in higher compressive strength of Geopolymer concrete. Arya Aravind and Mathews M Paul carried out research on mechanical properties of Geopolymer concrete reinforced with steel fiber. This study focuses on the compressive strength and split tensile strength of geopolymer concrete reinforced with steel fiber. Experiments were performed using the Box–Behnken experimental design. Box–Behnken experimental design is a type of response surface methodology. Response surface methodology is an empirical optimization technique for evaluating the relationship between the experimental outputs and factors called X1 , X2 , and X3 . For obtaining the results for Box Behnken design, analysis of variance has been calculated to analyze the accessibility of the model and was carried in Microsoft Office Excel 2007. It can be concluded that compressive strength of geopolymer concrete is gradually increased .

4.2Structural 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 were comparatively less than bubble deck slab. They have concluded from this paper that bending stresses in the bubbl 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.

V.METHODOLOGY

5.1.General

Study of Mix Design of M20 concrete and selection of ingredients of concrete mix as per the Mix Design (both OPCC and GPC). Ingredients selected are cement, sand and coarse aggregate for OPCC and for GPC cement is completely replaced with 70% flyash, 15% GGBS and 15% glass powder. NaOH solution of 12M is added in place of water for GPC.
•Preparation of beam samples with conventional concrete and geopolymer concrete. •Testing of RC beam (750mm x 150mm x 150mm) for bending and deflection.
•Preparation of test samples of Ordinary Portland cement and geopolymer cement concrete beam with plastic balls as partial tension zone replacement. •Testing of samples for bending and deflection.
• Preparation of sample beams with replacement of tension zone concrete with bubble mesh and provision of shear reinforcement.

• Comparing the results of OPCC and GPC beams to draw conclusions.

VI.MATERIALS USED & METHOD ADOPTED.

6.1 Portland PozzolanaCement (PPC): Itis a variation of OPC which includes a mixture of a pozzolanic material which is known to increase the strength of concrete and reduce the amount 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 20 grade.

6.2 Fine Aggregates: used Natural River sand size 4.75mm and below confirming to zone 3 of IS 383-1970 is being used as the fine aggregate.

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

6.4. Hollow Plastic Spherical Bubbles: The hollow plastic spherical bubbles used in this project are manufactured from recycled plastic of diameter 35 mm. The purpose of using recycled 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.

6.5. Water: Water is the key ingredient, which when mixed with cement, 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 most critical factor in the production of "perfect" concrete. PH value of water used for concreting should be greater than 6 and should be potable.

6.6. Steel Reinforcement: Steel is an alloy of 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 & 10 mm diameter steel bar for main reinforcement and distribution reinforcement. Reinforced Steel of 4-8mm bars for main steel & 6-6mm bars for stirrups @ 68.57mm c-c spacing and spherical bubbles (HDPE) of 35mm dia. are reinforced in Beam Mould of size 75cm x 15cm x 15cm.

VII. Mix Design for M20 Grade of Geopolymer Concrete Using Proposed Method. (using IS456-2000)

7.1.Following preliminary data is considered for the mix design:

1. Characteristic compressive strength of Geopolymer Concrete (fck) = 20MPa.
2. Type of curing: By applying wetgunny bags and tested after 3 days
gunny bags and tested after 3 days
3. Workability in terms of flow: 25–50 % (Degree of workability—Medium)
4. Fly ash: Fineness in terms of specific surface: 430 m2 /kg
5. Alkaline activators (Na_2SiO_3 and NaOH)
(a) Concentration of Sodium hydroxide in terms of molarity: 13 M
(b) Concentration of Sodium silicate solution: 50.32 % solid content
6. Solution-to-fly ash ratio by mass: 0.35
7. Sodium silicate-to-sodium hydroxide ratio by mass: 1.0
8. Fine aggregate (a) Type: Natural river sand confirming to grading zone-I as per IS 383 [20], F.M. = 3.35
(b) Water absorption: 3.67 %
(c) Water content: Nil
9. Coarse aggregate
(a) Type: Crushed/angular
(b) Maximum size: 20 mm
c) Water absorption: 0.89 %
(d) Moisture content: Nil.

7.2. Design Steps

1. Target mean strength Fck = 38.25 MPa
Fck=fck + 1.65xS=20+1.65X5=38.25Mpa

7.3. Selection of quantity of fly ash the quantity of fly ash required is 405 kg/m3 for the Ytarget mean strength of 38.25 MPa at solution-to-fly ash ratio of 0.35 and for 430 m2 /kg fineness of fly ash

7.4. Calculation of the quantity of alkaline activators 1628 S.V.

Calculate the quantity of alkaline activators considering:
Solution/Fly ash ratio by mass = 0:35
i:e: Mass of (Na_2SiO_3 + NaOH) /Fly ash =0:35
Mass of Mass of (Na_2SiO_3 + NaOH) =141.75kg/m^3
Take the sodium silicate-to-sodium hydroxide ratio by mass of 1
Mass of sodium hydroxide solution (NaOH) = 70.88 kg/m3
Mass of sodium silicate solution (Na_2SiO_3) = 70.88 kg/m3

7.5. Selection of water content For medium degree of workability and fineness of fly ash of 430 m2 /kg, water content per cubic meter of geopolymer concrete is selected from Table 2 Water content = 110 kg/m3

7.6. Adjustment in water content

For sand conforming to grading-I, correction in water content is taken from Adjustment in water content= -1.5 % (using IS 383(20)

Total quantity of water required =
110 -(1.5/100)x110= 108.35 kg/m3
Water content in alkaline solutions =
141.75 -62.96 =78.79 kg/m3
• Calculation of additional quantity of water = [Total quantity of water] − [Water present in alkaline solutions]
= 108.35 − 78.79 = 29.46 kg/m3
Selection of wet density of geopolymer concrete wet density of geopolymer concrete is 2,528 kg/m3 for the fineness of fly ash of 430 m2 /kg
Selection of fine-to-total aggregate content Mix Design of Fly Ash Based Geopolymer Concrete.

7.7. Calculation of fine and coarse aggregate content

Total aggregate content =(Wet density of GPC) - (Quantity of fly ash+ Quantity of both solutions extra water)
=2.528-(405 + 141.75 +29.46)
= 1951.79 kg/m3
Sand content = (Fine / total aggregate content in %) x (Total quantity of all-in-aggregate)
=(35/100) x 1951.79
=683.13kg/m^3
Coarse aggregate content = (Total quantity of all-in-aggregate) - (Sand content)
=1951.79-683.13
= 1268.66 kg/m3

VIII. Calculation of materials For The Concrete Deck Beam-

Dimensions of Concrete Deck Beam-

Length = 750mm width = 150mm Thickness = 150 mm
Wet volume of Solid Deck beam = 0.750m x 0.150m x 0.150m
= 0.016875 m^3
Dry Volume of Concrete Deck Beam
=0.016875 x 1.54= 0.0259m^3
Required quantity of Coarse aggregate for solid deck slab:
= quantity of Coarse aggregate for 1 m^3 x Space available of SD volume of 1m^3
= 1268.66 x 0.0259
=29.67 kg
Required quantity of fine aggregate for Concrete Deck Beam:
= quantity of fine aggregate for 1 m^3 x Space available of SD volume of 1 m^3
=683.13 x 0.0259
= 17.35 kg
Required quantity of Cement for Concrete Deck Beam:
= quantity of Cement for 1 m^3 x Space available of SD volume of 1 m^3
= 425.75x0.0259
=11.02 kg
Required quantity of water for Concrete Deck Beam :
= quantity of water for 1 m^3 x Space available of SD Volume of 1 m^3
= 108.35 x 0.0259
= 2.80 liter

4.3. Calculation of Materials for the Bubble Deck Beam:
Dimensions of one Plastic Sphere Ball: Diameter = 60 mm
Radius = 30 mm
Volume of one Plastic Spherical Ball = 4/3 x π x r^3
= 4/3 x π x 0.03^3
= $1.13\times10^{-4} m^3$
No. of Spherical balls used = 08 No.
Now the actual volume of spherical balls = No. of balls x Volume of one balls
= 08 x 1.13×10^{-4}
= 9.04×10^{-4} m^3
Actual volume of space for concrete in Beam =
vol. of solid deck Beam - vol. of spherical balls
= 0.0259 m3 - 9.04×10^{-4} m^3
=0.025m^3

8.1Calculation for material required of the bubble deck Beam:

Required quantity of Coarse aggregate for solid deck Beam:
= quantity of Coarse aggregate for 1 m^3 x Space available of BD volume of 1m^3
= 1268.66 x 0.025
= 31.71Kg
Required quantity of fine aggregate for solid deck Beam:
= quantity of fine aggregate for 1 m^3 x Space available of BD volume of 1 m^3
= 683.13 x 0.025
= 17.07 kg
Required quantity of Cement for solid deck Beam:
= quantity of Cement for 1 m^3 x Space available of BD volume of 1 m^3
= 425.75 x 0.025
= 10.64 kg
Required quantity of water for solid deck Beam:

= quantity of water for 1 m^3 x Space available of BD Volume of 1 m^3

=108.35 x 0.0259 = 2.80 liter

=683.13kg/m^3

= 1268.66 kg/m3

8.2.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 isnecessary to reduce the amount of concrete to reduce the cost of project. And due to its higher density, weight of the structural members also increases.

Volume of beam (V1) = 0.750m x 0.150m x 0.150m

= 0.016875 m^3

Volume of one Plastic& Rubber Spherical Ball = 4/3 x π x r^3

= 4/3 x π x 0.03^3

= $1.13 \times 10^{-4} m^3$

% Reduction ofconcrete = v2 / v1

= 1.13×10^{-4}/ 0.016875

= **6.69 %**

Avg weight of conventional beam (w1) = 41.30 kg

Average weight of bubbled beam (w2) = 37.55 kg

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

= **9.07 %**

IX.RESULT & DISCUSSION EXPERIMENTAL INVESTIGATION

9.1 General

The results obtained by experimental test conducted on hardened concrete for conventional and Bubbled Plastic Cube/ Beam, Bubbled Rubber Cube/Beam.

9.2 Compressive Strength Test

Compressive strength test out is completed at particular ages about cubes. Cube specimens of size 150mm ×150mm × 150mm were cast for The concretewas filled in distinct layers inside the mould and layer was compacted with the aid of tamping fishing rod.

The example of beauty was taken out of mould following 24 hours, treated in tidy water to get 7, 14, 28 days and nights. After 7, 14, and 28 days of solving, the individuals are applied for, wiped dry out and then analyzed for compressive strength according to Indian Common in compressive strength of the specimen calculated using the formula,

fck = P/A

Where, fck = Compressive strength (N/mm²)

P = Ultimate load (N)

A = Loaded area (150mm × 150mm)

9.3.Observation Table

No.of Cube casted For Test	Age of Concrete in(Day's)	Average compressive strength in N/mm²		
		CC	BPC	BRC
3	3	8	7.95	8.10
3	7	12.20	12.10	12.30
3	28	19.95	19.90	19.94

Where,
CC= Conventional Cube.
CB = Conventional Beam.
BPC/B= Bubbled Plastic Cube/ Beam.
BRC/B= Bubbled Rubber Cube/ Beam.

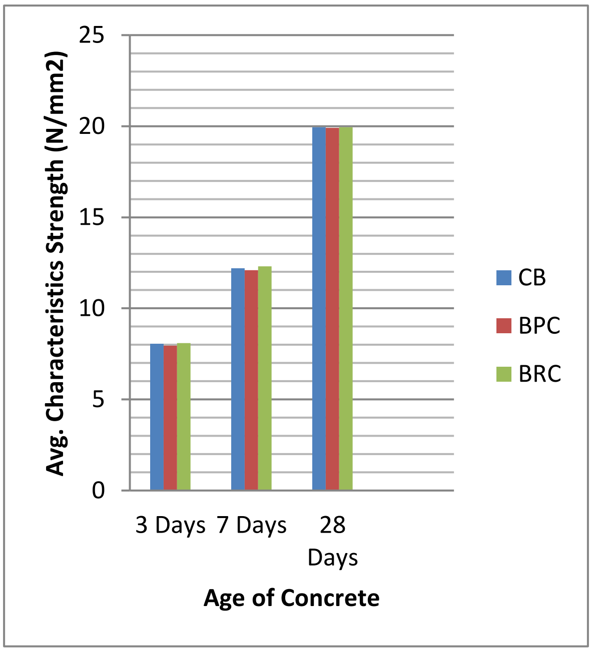

Fig 9.1COMPARISION OF COMPRESSIVE STRENGTH OF CONCRETE

9.4.FLEXURAL STRENGTH TEST

The example of standard crystal of 750 × 150 × 150 mm was utilized to decide the flexural quality of cement. The material was gauged and the materials were blended physically. The solid was filled in various layers in shape and each layer was compacted with the assistance packing pole. The example was expelled from form following 24hours, relieved in clean water for 28 days of restoring, the examples are taken out, cleaned dry and afterward tried for flexural quality according to Indian Standard in general testing machine

fb = 3 (PL/bd2) N/mm2
where, P = Ultimate load (N)
L = centre to centre distance between the supports (700mm)
b = breadth of the specimen (150mm)
d = depth of the specimen (150mm)

Fig 9.1COMPARISION OF COMPRESSIVE STRENGTH OF CONCRETE

9.5.Observation Table

Where,
CC= Conventional Cube.
CB = Conventional Beam.
BPC/B= Bubbled Plastic Cube/ Beam.
BRC/B= Bubbled Rubber Cube/ Beam

No.of Cube casted For Test	Age of Concrete (Day's)	Load at Peak(KN)			Flexural strength in N/mm²		
		CC	BPC	BRC	CC	BPC	BRC
3	3	30.73	29.85	29.90	20.48	19.90	19.95
3	7	31.75	30.28	30.60	21.16	20.18	20.40
3	28	33.30	33.10	34.10	22.20	22.06	22.73

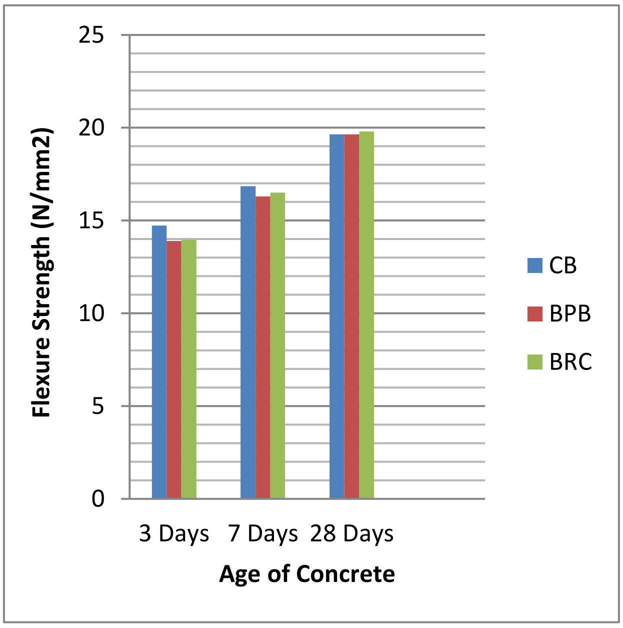

Fig.9.2 COMPARISION OF FLEXURE STRENGTH OF CONCRETE

X. CONCLUSION

• The flexural behavior of the beam with replaced balls are tested and compared with conventional beam in this study.
• Flexural behavior of conventional beam and beam with balls are marginally similar.
• Replacing the concrete by balls in compression zone does not exhibit significant
change in the load carrying capacity of the beams .
• In this study compared to other ball beams had more load carrying capacity, and deflection of the beam is controlled.
• Deflection of the ball beam is considerably lower than the conventional beam.
• By replacing concrete with these balls in reinforced concrete beams had no need of additional labors and time
•Reduction of weight of concrete 6.06% as compare to convetinal beam.
•Reduction of weight 7.95 % as compare to convetinal beam.

XI.Recommendations for use: .

•Use For constructing all type of building especially single storey & each and every roof floor
Story & each and every Roof floor.
•Best for larger span hall such as Theatre & Auditoriums
•Use in parking areas

Future scope
•In future we can extend the study for behavior of bubbled beam at beam-column junctions.
•As bubble beam lacking in strength further study can be made on improving strength of the same.
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