Strength Investigation Report on Bubble Deck Beam &Reinforced Concrete Beam

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Abstract- *Concrete is the majority used man-made building material in the whole world. It is almost all-important quality is its versatility & the ability to design the concrete of any required properties as reported by the environment. The researchers have shown that every ton of cement manufacture releases half a ton of carbon dioxide (CO2), so there is an instant need to regulate cement usage. In structural constructions, the beam is a very important structural member to carry the load of the slab. A Bubble Deck Beam is a methodology of virtually eliminating all concrete from the middle of a Beam, which is not performing any structural function, thereby dramatically reducing its dead load. Concrete is good in compression and hence is more useful in the compression region than in the tension region. A BD beam is a beam whose core is re-established with Spherical balls of discrepant sizes and shapes. Usually, the BD system amalgamates the advantage of factory-manufactured elements in a controlled state along with on-site completion. Some of its major advantages are lower total cost, diminish the use of material, enhanced of its structural efficiency, decreased of construction time, and is a green technology. In this project, the ineffective concrete in the Centre of the beam is replaced with High-density polyethylene hollow spheres. Using M30 & M60 grade of concrete, 36no of beams with and without spherical plastic balls was cast to compare weight and compressive & flexural strength.*

Keywords- Bubble deck beam, Slump-cone, Compaction factor, Compressive strength & Flexural strength.

I. INTRODUCTION

1.1 CONCRETE:

Concrete is a development material made out of bond, fine totals (sand), and coarse totals blended in with water, solidifying with time. Portland bond is the usually utilized kind of bond for the creation of Cement. Solid innovation manages the investigation of properties of Cement and its handy applications. In a structure development, concrete is utilized for the development of establishments, sections, shafts, chunks and other burden-bearing components. Concrete is a composite material comprised of mostly water, total, and bond. The physical properties wanted for the completed material can be achieved by adding added substances & fortifications to the solid blend.

Concrete is a blend of bond, for the most part Portland cement, course & fine totals (consider is a coarse rock & fine as sand, however different materials might be utilized). At the point when bond is blended in with water & the suitable totals, it gets plastic (liquid), and it is put in structures (moulds) to make the shape of the building. Hydration, a response between the dry segments of the bond & water, makes the solid set up, or solidify into a stone-like material that is the establishment (truly) of the development business today.

1.2 Properties of Concrete: For the most part, concrete is a material having high compressive quality than to rigidity. It has lower ductile pressure; it is commonly fortified with specific materials that are solid in strain like steel. The versatile conduct of Cement at low feelings of anxiety is generally steady yet at higher, feelings of anxiety start diminishing as grid splitting creates. Concrete has a low coefficient of warm extension, and its development prompts shrinkage. Because of the shrinkage and strain, every single solid structure breaks somewhat. Concrete inclined to crawl when it is exposed to long-term powers. For the applications different tests be performed to guarantee the properties of cement compare to the particulars. Various blends achieve various qualities of cement of solid fixings, which are estimated inpsiorMpa. Various qualities of cement are utilized for various reasons for developments. On the off chance that the solid must be light weight low-quality cement might be utilized.

The lightweight cement is accomplished by the expansion of lightweight totals, air or froth, the symptom is that the quality of solid will get decreased. The solid with 3000-psi to 4000-psi is often utilized for routine works. Despite the fact that the solid with 5000-psi is progressively costly choice is economically accessible as an increasingly tough one. For bigger common tasks the solid with 5000-psi is often utilized. The solid quality over 5000 psi was regularly utilized for explicit structure components. For instance, the skyscraper solid structures made out of the lower floor segments may utilize 12,000 psi or more quality cement, to keep the sections measures little.

1.3 Construction Waste in India: Concrete is a composite material comprised of chiefly water, total bond. The physical properties wanted for the completed material can be accomplished by adding substances and fortifications to the solid blend. A Strong mass that can be effectively formed into wanted shape can be formed by blending these fixings in specific extents. Over the time, a hard grid framed by the bond ties the remainder of the fixings together into a solitary hard (inflexible) strong material with numerous utilization, for example structures, asphalts & so on., The innovation of utilizing concrete was embraced before on enormous scale by the old romans, & the significant piece of solid innovation was profoundly utilized in the roman empire. The open air theatre in Rome was assembled to a great of cement & the arch of the pantheon is the world’s biggest unreinforced solid structure. After the breakdown of Roman Empire in the mid-eighteenth century, the innovation was re-spearheaded as the utilization of cement has gotten uncommon. Today, the generally utilized man made material is concrete as far as tonnage. All through the world Ordinary Portland Cement is perceived significant development material. Customary Portland concrete is the ordinary structure material that really is liable for about 5%-8% of worldwide CO2 emanations. This natural issue will probably be expanded because of exponential interest of Ordinary Portland Cement (O.P.C.). 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 (shape of cross-section), length, and their material Beams classified on basis of support are simply supported, fixed, overhanging, continuous, cantilever etc. The loads carried by a beam are transferred to columns, walls, or girders, which then transfer the force to adjacent structural compression members and eventually to ground. In light frame construction, joists may rest on beams. Internally, beams subjected to loads that do not induce torsion or axial loading experience compressive, tensile and shear stresses as a result of the loads applied to them. Typically, under gravity loads, the original length of the beam is slightly reduced to enclose a smaller radius arc at the top of the beam, resulting in compression, while the same original beam length at the bottom of the beam is slightly stretched to enclose a larger radius arc, and so is under tension. Concrete in beam is heavy, and 5% of the world's CO2 is created during the manufacture of the Cement that goes into it. Then there is the aggregate that is dug out and the trucks that have to carry it. Not only that, but most of the concrete that is in a beam isn't even needed; it is just a spacer between the bottom, where the reinforcing steel is in tension, and the top, where the concrete is in compression.

1.4 Bubble-Deck Technology

Concrete is heavy, and 5% of the world's CO2 is created during the manufacture of the Cement that goes into it. Then there is the aggregate that is dug out and the trucks that have to carry it. Not only that, but most of the concrete that is in a slab isn't even needed; it is just a spacer between the bottom, where the reinforcing steel is in tension, and the top, where the concrete is in compressionBubble-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.

Replacing this area with a grid of "voids" sandwiched between layers of reinforcing welded wire steel and an internal lattice girder yields a slab typically 35% lighter that performs like solid reinforced concrete. Once the steel lattice/void "sandwich" is concreted, it is then precast into panels of various sizes and craned into position on shoring. Once concrete is poured over the balls in the panels, the Bubble-Deck system effectively becomes, and behaves like, a monolithic two-way slab that distributes force uniformly and continuously. Bubble-Deck produces floors 20% faster with less formwork and beams, reduces construction costs by 10% and agrees with the 35% reduction in concrete use. "Off-site manufacturing, fewer vehicle movements and crane lifts and simple installation all combine to minimize operating as well as health & safety risks."

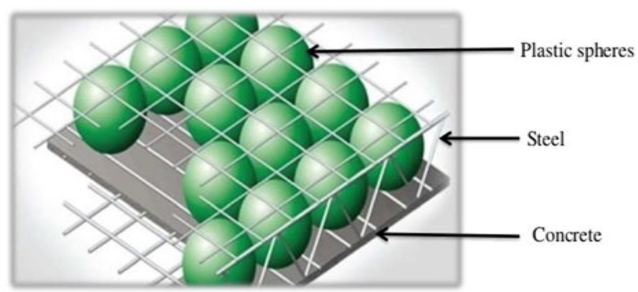

Fig. No.1: -Bubble Technology

II. LITERATURE REVIEW

1.Diyala Journal of Engineering Sciences Volume 6 No.2, June (2013) studied the stiffness values of Bubble Dec k slabs in comparison with solid slabs. The (BD2-bu80 and BD3-bu100) plastic spheres in reinforced concrete slabs of size (B/H=0.51, 0.64 and 0.80), were subjected to a flexure test in which they results show some one-way flexural cracks and lower stiffness indicating that their flexural capacities were good enough to use. The results were compared with reference solid slabs (without plastic spheres), (100%, 100% and 90%) applying the ultimate load of a similar reference solid slab but only (76%, 75% and 70%) of the concrete volume due to plastic spheres, respectively. Results obtained give the deflections under service load of Bubble Deck specimens to be a little higher than those of an equivalent solid slab. The concrete compressive strain of Bubble Deck specimens is greater than that of equivalent solid specimen.

2. AratiShetkar&NageshHanche (2015) did an experimental study on Bubble Deck Slab System with Elliptical Balls; the behaviour of Bubble Deck slabs is influenced by the ratio of bubble diameter to slab thickness. The bubbles were made using high density polypropylene e materials. Bubble diameter varies between 180mm to 450mm and the slab depth is 230mm to 600mm. The nominal diameter of the gaps is of sizes: 180, 225, 270, and 315. In this experiment, the applied force is from the bottom to the top of the slab, until the cracks occur in the slabs and the failure modes were recorded. Results obtain ned shows the better load bearing capacity in Bubble Deck can be achieved using the hollow elliptical balls, thereby Reducing g material consumption makes the construction time faster, and to reduce the overall costs. Besides that, result of the study also shows a reduction in deadweight up to 50%, which allow creating foundation sizes smaller.

3. **Structural Behaviour of Bubble Deck Slab** by P. PrabhuTeja, P.Vijay Kumar, S.Anusha, CH.Mounika, PurnachandraSaha(2015). 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 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 solid slab of same thickness.

4. M.Surendar, et al. (2016), did a numerical and experimental Study on Bubble Deck Slab with the sole aim of reducing the concrete in the centre of the slab by using recycled balls. Plastic hollow spheres balls were used to replace the in-effective concrete in the centre of the slab, thus decreasing the dead weight and increasing the efficiency of the floor and to enhance the performance of the bubble deck slab in moderate and severe seismic susceptibility areas. Finite element analysis (F.E.A.) was carried out by using the F.E.A. software A.N.S.Y.S. to study structural behaviour on the slab. The slab of conventional and Bubble deck slab was subjected to uniformly distributed load. The ultimate load, stress, deformation was measured by analytically. Conventional slab carried the stress of about 30.98MPa by applying the U.D.L. load of about 340kN and causes deflection of 12. 822mm.The bubble deck slab carried the stress of about 30.8MPa by applying the U.D.L. load of about 320kN and causes deflection of 14.303mm. The bubble deck slab can withstand 80% of stress when compared with conventional slab. Slight variation occurs in the deformation when compared to conventional slab. The stress and deformation results of bubble deck slabs were evaluated and compared with conventional slab, using finite element analysis. From the evaluation of these results, Bubble Deck Slab gives better performance than that of the conventional slab.

5. Experimental study on bubble deck slab by Mr. Muhammad ShafiqMushfiq, Asst. Prof. Shikha Saini and Asst. Prof. NishantRajori (2017).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. 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 an issue.

III. MATERIALS USED

3.1 Cement: The O.P.C. is ordered into three evaluations: specific 33 Grade, 43 Grade, 53 Grade contingents on the quality of 28 days. It has been conceivable to overhaul the characteristics of a bond by utilizing great limestone, present-day equipment's, keeping up better molecule size dissemination, better granulating & better pressing. By and extensive utilization of high evaluation bond offers numerous focal points for making more grounded Cement. Although they are minimal costlier than second rate bond, they offer 10-20% sparing in concrete utilization, and furthermore they offer many shrouded benefits. One of the most significant advantages is the quicker pace of improvement of solidarity.

Customary Portland Cement (O.P.C.) is the bond most appropriate to general cementing purposes. O.P.C. 53 evaluation affirming with I.S.: 12269-2013 is utilized. The bond is kept in an impermeable compartment and put away in the stickiness-controlled space to keep concrete from being presented to dampness.

3.2 Fine Aggregate: Degree alludes to the molecule size conveyance of totals. Reviewing is a significant property of total utilized for making concrete, in perspective on its pressing of particles, bringing about the decrease of voids. The impacts of waterrequestand bond substance of Cement. Evaluating is depicted as far as the combined rates of loads passing a specific A.R.E. sifter. IS 383-1970 determines four territories or zones for fine total reviewing. Table gives them scope of rate going for each zone.

Table No.1: Sand zones

Sand Zones	Type
Zone I	coarsest
Zone II & Zone III	moderate
Zone IV	best though sand

It is prescribed that fine totals complying with reviewing zone II or Zone III can be utilized in fortified Cement.

3.3 Coarse Aggregate: The total which is held over IS Sieve 4.75 mm is named as coarse total. The ordinary greatest size is step by step 10-20 mm; anyway, molecule evaluates to 40 mm or more have been utilized in Self Compacting Concrete. Whole reviewed totals are as often as possible superior to those persistently evaluatedwhich may costly grader inner grating and give diminished stream. As to attributes of various sorts of total, squashed totals will in general improve the quality as a result of interlocking of rakish particles, while adjusted totals improved the stream in view of lower interior grating. Locally accessible coarse total having the most extreme size of 20 mm was utilized in this work. The totals were washed to evacuate residue and soil and were dried to surface dry condition. The totals were tried according to Seems to be: 383-1970.

3.4. Water: Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes & streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling isnecessary.When it is suspected that water may contain sewage, mine water, or wastes from industrial plants or canneries, it should not be used in concrete unless tests indicate that it is satisfactory. 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. P.H. value of water used for concreting should be greater than 6 and should be potable

3.5 Plastic: There are two classes of PLASTIC WASTE: "F" is made from burning anthracite and/or bituminous coal, and "C" is produced from lignite or sub-bituminous coal. In Canada, there is a further distinction. When the lime content is 8-20 percent, it is classified Cal, and when it is higher, it is class C.

In the United States and other parts of the world where U.S. standards have been adopted, the chemical part of the specification requires only a combined total of silica, alumina, and iron oxide. It does not specify the amount of silica that reacts with lime to produce added Strength. The alumina content could be high in PLASTIC WASTE, which could be detrimental because more sulphate to control its reactivity might be required. Sulphate is added to the Cement to control only the setting reactions of the aluminates and ferrites in the Cement. However, the amount is limited because expansive reactions are possible after the concrete has set. This amount of sulphate doesnottakeintoaccounttheextraaluminatesthatcanbeadded. When PLASTIC WASTE is used. Too much iron oxide will retard the setting time.

Both class C plastic waste and slag have about 35 percent silica and much lower calcium oxide than Portland cement. In most cases, lower calcium oxide means better durability. In some plastic waste, alumina and iron oxide can be quite high, leading to lower strength and unusual setting time problems. The carbon content was reported in some to be so high that it was beyond the special footnoted exception in ASTM C618. Commercial production of plastic balls runs from 1/8" (0.125", 3.175 mm) to over 1 1/4" (1.25", 31.75 mm) in 1/32" (.03125", .79375 mm) increments. Also, some of the metric (millimetre) sizes are commercially available. We will custom manufacture precision plastic balls even smaller than 1/8" (0.125", 3.175 mm) all the way up to seventeen inches (17", 431.8 mm). Large diameter plastic balls from eight inches (8", 203.2 mm) to thirteen inches (13", 330.2 mm) are common, every day, production items for us.

The quality specification for precision plastic balls is very different from that for precision metal balls. Grade 3 plastic balls must be spherical within three thousands of an inch (0.003", 0.0762 mm) and be within the specified diameter within plus or minus three thousands of an inch (0.003", 0.0762 mm). Grade 2 plastic balls must be spherical within two thousands of an inch (0.002", 0.0762 mm) and be within the specified diameter within plus or minus two thousand of an inch (0.002", 0.0508 mm).Grade 1 plastic balls must be spherical within one thousands of an inch (0.001", 0.0254 mm) and be within the specified diameter within plus or minus one thousands of an inch (0.001", 0.0254 mm). In addition to these grades, we also supply a precision machined grade ball that is spherical within five thousands of an inch (0.005", 0.127 mm), and must be within the specified diameter within plus or minus five thousands of an inch (0.005", 0.127 mm).Modified plastic balls can be produced with flats, holes, threads or whatever. Send a sketch of drawing to our order desk for immediate quotation on your modified plastic ball requirements. There is no minimum quantity requirement for these special balls. Bal-tec will custom manufacture complete balls, or partial spheres from any workable material, metal (except lead), plastic, or ceramic.

3.5.1 Hollow Plastic Spherical Bubbles: Hollow H.D.P.E. balls range in diameter sizes from 0.25" up to 6 inches in natural, black, and orange colours. High mass transfer efficiency Low pressure drops for considerable energy savings High resistance to nearly all mineral and organic acids and derivatives Partly resistant to alkalis commonly used in oil and gas applications, salt-eliminating water tanks, coagulate water tanks, water treatment, and environment protection fields.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.

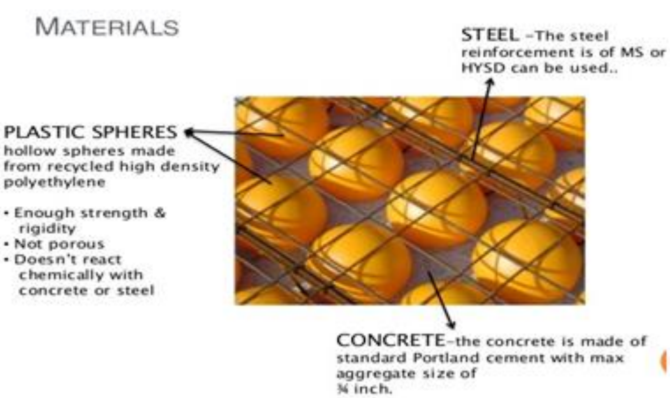

Fig. No: - 2Hollow Plastic Spherical Bubbles

3.6 Steel Reinforcement: Steel is an alloys 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 & 8 mm diameter steel bar for main reinforcement and distribution reinforcement. Reinforced Steel of 4-8mm bars for main steel & 6-6mm bars for stirrups @ 75 mm c-c spacing and spherical bubbles (H.D.P.E.) of 35mm dia. are reinforced in Beam Mould of size 40cm x 10cm x 10cm.

Fig.No 3 Bubble deck beam module sample

IV. DESIGN MIX

STIPULATIONS FOR PROPORTION (M-30)

Grade designation	=	M-30
Type of cement	=	OPC 53 grade
Maximum nominal size aggregate	=	20 mm
Maximum water cement ratio	=	0.45
Workability	=	100mm (slump)
Exposure condition (reinforced concrete)	=	Severe
Degree of supervision	=	Good
Type of aggregate	=	Crushed angular aggregate
Minimum cement content	=	320kg/m^3

TEST DATA FOR MATERIAL:-

Cement used	=	OPC 53
Specific gravity of cement	=	3.14
Specific gravity		
I. Coarse aggregate	=	2.74
II. Fine aggregate	=	2.7
Water absorption		
i. Coarse aggregate	=	0.1 percent
ii. Fine aggregate	=	0.3 percent
Free moisture in		
I. Coarse aggregate	=	Nil
II. Fine aggregate zone	=	1

MIX PROPORTION

- Cement = 492.5 kg/m^3
- Water = 197.16 kg/m^3
- Fine aggregate = 772.12 kg/ m^3

- Coarse aggregate = 948.21 kg/m^3
- W/C = 0.40

Table 2: M-30 Mix Proportion

Cement	F.A	C.A	Water
492.5	772.12	989.21	197
1.0	1.56	2.0	0.40

STIPULATIONS FOR PROPORTION (M-60)

Grade designation = M-60
Type of cement = OPC 53 grade
Maximum nominal size aggregate = 20 mm
Maximum water cement ratio = 0.31
Workability = 100mm (slump)
Exposure condition (reinforced concrete) = Severe
Degree of supervision = Good
Type of aggregate = Crushed angular aggregate
Minimum cement content = 360kg/m^3

MIX PROPORTION

- Cement = 492.5 kg/m^3
- Water = 197.16 kg/m^3
- Fine aggregate = 772.12 kg/ m^3
- Coarse aggregate = 948.21 kg/m^3
- W/C = 0.40

Table 3: M-60 Mix Proportion

cement	F.A	C.A	Water
635.48	688.02	948.02	197
1.0	1.08	1.49	0.31

V. EXPERIMENTAL RESULTS

5.1 Slump Cone Test: It is conducted to determine the slump cones of bubble deck concrete mix & reinforced concrete mix.it was found that Reinforced Concrete mix values nearly to the Bubble Deck concrete mix.

Table 4: Slump values results of M-30 and M-60 Grades

Ratio	Slump values of M-30 in mm	Slump values of M-30 in mm
RC Mix	86	76
BD Mix	84	73

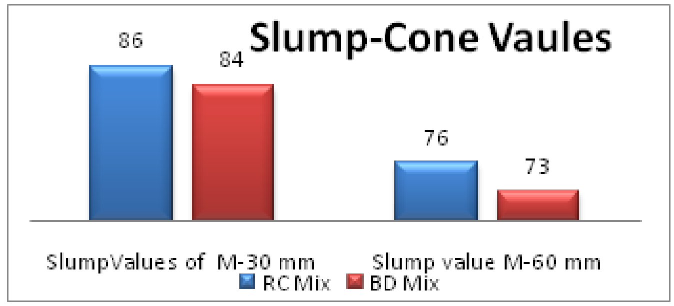

Fig. 4:comparison of workability results of M-30 &M-60

5.2 Compaction Factor Test: The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability and normally used when concrete is to be compacted by vibration. It is conducted to find the values of compaction factor test of RC mix & BD mix.

Table 5: Compaction factor values for M-30& M-60 Grades

Ratio	Compaction factor of M-30	Compaction factor of M-60
RC Mix	0.82	0.83
BD Mix	0.815	0.825

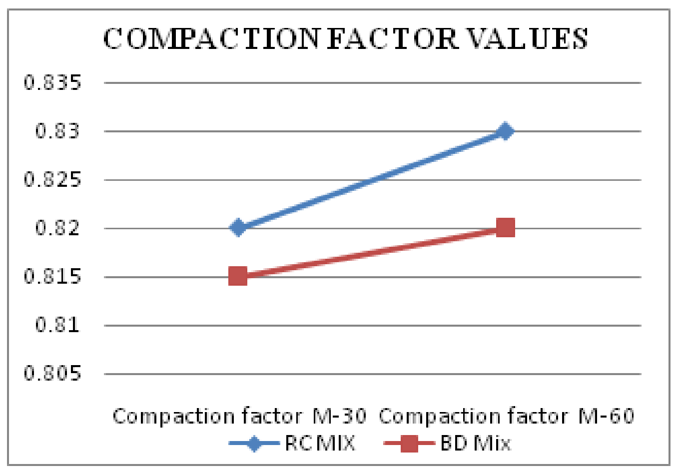

Fig. 5: Compaction factor results of M-30& M-60 Grades

5.3 Compressive Strength Test: It is conducted to determine Compressive strength of the Cube. It was found that BD mix all values near to the RC mix of M-30 & M-60 Grades.

Table 6:compressive strength test results of M-30& M-60 Grades at 3 and 7 & 28 days

No.of Cubes Casted for Test	Age of Concrete	RC Mix M-30	BD Mix M-30	RC Mix M-60	BD Mix M-60
3	3 Days	13	12.80	25.41	24.10
3	7 Days	20	19.05	39.25	38.50
3	28 Days	31	29.10	59.85	58.90

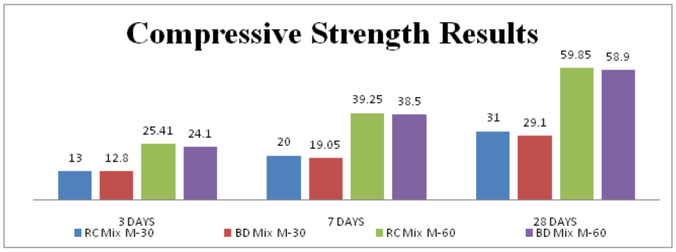

Fig. 6: compressive strength results of M-30 & M60 Grades at 3 and 7 & 28 days

5.4 Flexural Strength Test: Flexure tests are generally used to determine the flexural modulus or flexural strength of a material. It was found that BD mix all values near to the RC mix of M-30 & M-60 Grades.

Table 7: Flexural strength test results of M-30& M-60 Grades at 3 and 7 & 28 days

No.of Cubes Casted for Test	Age of Concrete	RC Mix M-30	BD Mix M-30	RC Mix M-60	BD Mix M-60
3	3 Days	22.54	21.80	51.80	50.57
3	7 Days	24.68	23.50	53.70	52.28
3	28 Days	26.55	25.43	55.46	54.30

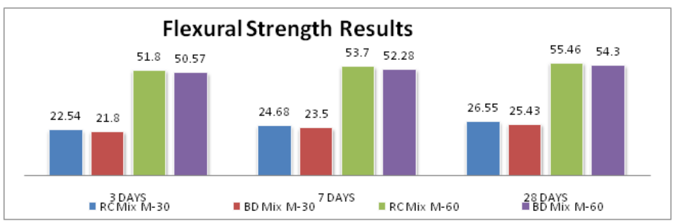

Fig. 7: Flexural strength test results of M-30& M-60 Grades at 3 and 7 & 28 days

5.5. Estimation of Saved Amount of Concrete: Concrete is mixture of Cement, sand, aggregate and water. The amount of concrete directly affects the cost of project hence it is necessary to reduce the amount of concrete to reduce the cost of project. And due to its higher density, weight of the structural members Also increase.

Volume of beam (V_1) = 0.4m x 0.10m x 0.10m = 0.004 m^3
Volume HDPE Balls (V_2)= 0.785 x 0.035^3 x 9 (no's)
= 3.03 x 10^{-4} m^3
Percentage (%) of Reduction of concrete= V_2/ V_1
= 3.03 x 10^{-4} / 0.004
= 7.58 %
Average weigh.t of conventional beam (w_s) = 12.41 kg
Average weight of bubbled beam (w_v) = 11.37 kg
Percentage (%) of Reduction of weight
$= (Ws - Wv) \div Ws \times 100$
$= (12.41 - 11.37) \div 12.41 \times 100$
= 8.38 %

VI. CONCLUSION

- From the corresponding table no: 6 &graph no: 6 compressive strength results of the R.C mix & BD mix design of 30 & 60 grades values closer.
- From the corresponding table no: 7 & graph no: 7 flexural strength results of the RC mix& BD mix design of M- 30 &M-60 grades values closer.
- Concrete reduction of 7.58% of as compared to R.C Beam.
- Weight reduction of 8.38% of as compared to R.C Beam

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