Experimental study on replacement of coarse aggregate by EPS beads in concrete to achieve lightweight concrete

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Abstract - *Increasing the greater demand for construction materials. This pattern will have absolutely more prominent effect on the economic system of any nation. In this project work, try to address the option of using Expanded Polystyrene (EPS), It is a non-biodegradable waste material which is coming from packaging industry. Concrete has to be designed based on density factor to accomplish reduction of the concrete self-weight with is ranging from 2000kg/m^3 to 990kg/m^3 total volume of eps 0-100% and water cement ratio 0.40 Structural self-weight is quite important it shows a maximum portion of the load details. Substituting partially or completely the coarse part of low weight aggregate (EPS Beads) with normal aggregates produces lightweight concrete that can achieve a reliable decent compressive strength. Substitution of various percentage of eps beads according to desirable design details for different proportion. Various test was conducted for fresh and harden concrete to know physical and mechanical properties of concrete at age of 7,14 and 28days. The outcome indicates that increasing the quantity of EPS beads there will be decreasing strength of concrete with reduction in density.*

***Key Words*: Lightweight concrete, Construction materials, EPScrete, Special concrete, Building materials, Low density concrete etc…**

1.1 INTRODUCTION

With the greater requirement for construction materials., For sustainable improvement there should essential to use alternative materials. Concrete is most flexible material for construction of building. In basic structural applications, the structure self-weight is quite important it shows a maximum portion of the load details. Substituting partially or completely the coarse part of low weight aggregate with normal aggregates produces lightweight concrete that can achieve a Reliable decent compressive strength. With the Industrial advancement and mass construction in different parts of the world, the pollution contamination levels and shortage of construction materials have reached the highest level. In the present day construction, it is utilized as a base or sub level aggregate in floor materials and in addition washrooms in structures and asphalt construction. The light-weight concrete having greater demand in present day development applications, for example, offshore structures, tall buildings and long spans bridges. This intrigue rises from the simplify size of maximum load bearing components, and the better thermal properties of lightweight analyzed than normal concrete. Lightweight concrete can be acquired by inserting air or foam into the cement paste or by completely or partially replacing the coarse aggregate with low-weight and especially minimal cost of the element. lightweight aggregates are extensively characterized into two types: Natural (e.g., diatomite, pumice and volcanic ash) and Artificial (e.g., perlite, mud, sintered fly fiery debris and expanded shale). Expanded Polystyrene beads are a generally utilized as aggregates and can be effectively joined into concrete or mortar to make light-weight concrete with a extensive variety of densities.

1.2 Expanded polystyrene (EPS)

Expanded polystyrene (EPS) is a plastics substantial which is contained around 98% air and 2% polystyrene. These are light in weight comprising of fine circular shaped particles. It's like closed cell arrangement cannot absorb water. It as decent thermal and sound resistance qualities and additionally impact resistance. EPS material is non-biodegradable. The waste material which is coming after packing industry. It makes transfer issue. Using pulverized polystyrene particles in concrete are profitable waste transfer strategy. There are numerous benefits to be chosen since the utilization of lightweight concrete. These incorporate smaller loads amid at construction Increased thermal resistance and decreases self-weight in structures, Lightweight concrete is for the most part recognized as concrete having a density of around 1800 kg/m^3 or less. The current examination was taken up, keeping mainly two focuses, polystyrene waste transfer from the perspective of environment and replace with normal aggregate. The present study goes for usage and the suitability of EPS beads as coarse aggregate.

1.3 SCOPE AND OBJECTIVES

- To evolve a light weight concrete which provides thermal and sound insulation and also aesthetically good appearance.
- To evolve a light weight concrete which can be used at various sections of a building.
- The important objective of this investigation is to study the strength features of concrete containing different proportions of EPS beads and replacement to natural coarse aggregate, like compressive strength, tensile strengths and

flexure test of light weight concrete comprising Expanded Polystyrene beads.

- To know the essential properties of materials used as a part of the concrete and design the mix for conventional concrete
- To determine the effect on partial replacement on EPS beads with variable percentage by weight of coarse aggregate, in properties of fresh concrete.
- To determine the effect on partial replacement on EPS beads with variable percentage by weight of coarse aggregate, in properties of hardened concrete.
- To study the durability properties of EPS concrete.
- To know the behavior of EPS concrete on density compared to conventional concrete mixes.

2. LITERATURE REVIEW

1. Ben Sabaa and Sri Ravindrarajah

They examined the building properties of expanded polystyrene aggregate (EPS) concrete with somewhat substituting normal coarse aggregate with chemically treated approximate volume of EPS at the stages of 30, 50. and 70%. Finally observe that unit weight, compressive strength, drying shrinkage and creep increases by increasing EPS substitution in concrete

2. Miled, K., K. Sab and R. Le Roy

They were explored the Particle size impact of the polystyrene beads on the compressive strength of EPScrete. It was watched that smaller the size of EPS beads, increases the concrete compressive quality. for a similar concrete porosity.

3. Abdulkadir Kana and Ramazan Demirbodaba

They have done an exploratory examination on the impact of the proportion of eps beads to cement in concrete. By this trial and study they carried out EPS concrete. It has been discovered that the density of EPScrete has been altogether affected by the Portland Cement/EPS proportion. slump value than the w/c ratio are affected by Higher Densities.

4. E.M. Mbadike and N.N. Osadebe

made a study for the assessment of concrete manufactured from polystyrene beads. It was also found that the strength development of polystyrene concrete increases with increase in hydration period.

5. Zaher Kuhail

This Study works on the qualities of lightweight concrete comprising of polystyrene, coarse aggregate, cement and water. by this it has been demonstrated that suggested mixes is extremely good strength qualities of to 200 kg/cm^2 with a lower density. The chemical and mechanical properties are discussed about with a specific polystyrene behavior under different environments such as field usage, the workability of the mix will be higher at a lower w/c proportion. This study conclude that the mixing technique of lightweight concrete is exceptionally very easy, cheap and do not require complex apparatus machineries.

3. MATERIALS AND METHODOLOGY

3.1 Cement

Cement is the binder material which sets and solidifies when it dries furthermore effortlessly ties with alternate materials. In the modern history concrete was made from the crushed rock with burnt lime as the binder the materials required for the cement production are silica. lime, iron, oxide and alumina the oxide composition responsible for the various properties of cement RAMCO Portland pozzalona flyash based cement (PPC) has been used.

3.2 Aggregates

Aggregates are generally classified into two group sizes, coarse and fine. In so many cases two or more actual sizes of material has been used, because of a further subdivision by size of material either present in one or both of the groups
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3.3 Expended polystyrene (EPS) Beads

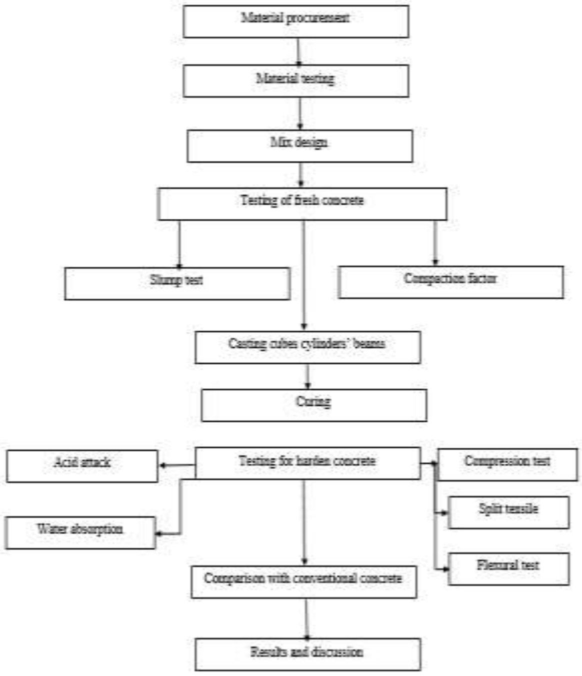
Expended polystyrene (EPS) is a plastics substantial which is contained around 98% air and 2% polystyrene. These are light in weight comprising of fine circular shaped particles. Its like closed cell arrangement cannot absorb water. It as decent thermal and sound resistance qualities and additionally impact resistance. EPS material is non-biodegradable. The waste material which is coming after packing industry.

Fig 3.1 Expended polystyrene (EPS)Beads

3.4 Water

Water is a one of the important ingredient in the concrete and this will help chemical reaction with cement. In the concrete, strength is mainly depending on the binding operation of hydrated cement gel. The water is added to get required consistency for the suitable workability. Water used for the concrete preparation must be fresh and potable, Ocean water and drainage water should not be used because of sulphate reaction,

4. METHODOLOGY



5. CONCRETE MIX DESIGN

Trials are carried out on general guide lines given as per IS 10626:2009 fundamental tests were done on the elements of concrete which are used in identifying the design mix parameters

5.1 STIPULATION FOR PROPORTIONING

Table 3.4 Proportions

Sl No	Description	Detail
1	Grade Designation	Target to density
2	Type of cement	PPC
3	Maximum nominal size of aggregates	20mm
4	Maximum nominal size of EPS Beads	1.34cm
5	Maximum water cement ratio	0.40
6	Workability	100mm
7	Exposure condition	Severe
8	Maximum cement content	400kg/m

5.2 TEST DATA OF MATERIAL

Table 3.5 Test Data of Material

Sl No	Material	Results
1	PPC	
	Specific Gravity	3.15
2	Coarse Aggregate	
	12.5mm	2.60
	20mm	2.72
	EPS Beads	0.011
3	Fine Aggregate	
	River Sand	2.6
4	Water Absorption By Coarse Aggregate	
	12.5mm	0.5%
	20mm	0.5%
	EPS Beads	0%
5	Water Absorption By Coarse Aggregate	
	River Sand	4.5%

Table 3.6 Percentage of Replacement of material for various mixes to get Desire density

Percentage Replaced				Density Achieved By Mix Design Kg/m^3
Mix Design -ation	Percentage of Coarse Aggregate	Percentage of Fine Aggregate	Percen -tage of EPS Beads	
M0	58%	42%	0%	2410
M1	55%	35%	10%	2261
M2	42%	30%	28%	1950
M3	31%	35%	34%	1801
M4	15%	35%	49.8%	1500
M5	0%	23%	77%	990

Table 3.7 Quantity of material taken for various mixes of concrete done for the present investigation

Mixes	Density Kg/m^3	Cement in Kg/m^3	Coarse aggregate Kg/m^3	EPS beads Kg/m^3	Fine aggregates Kg/m^3	Water Kg/m^3
M0	2410	400	1089	0	695	160
M1	2261	400	1056	0.78	645	160
M2	1950	400	995	1.48	598	160
M3	1801	400	593	2.67	645	160
M4	1500	400	292	3.89	645	160
M5	990	400	0	6.02	424	160

Here M0 is the control mix and Ml, M2, M3, M4 and M5 are trial mixes with partial and complete replacement of coarse aggregate by EPS beads to get desire density

6. TESTS CONDUCTED ON CONCRETE

6.1 SLUMP-TEST

This test conducted for determining workability of the fresh concrete. Testing method principle aggregate size should not exceed 20mm as per IS 456:2000

6.2 COMPACTION FACTOR TEST

Compaction factor test is an alternative test done to decide the workability of concrete which is fresh Apparatus used is compaction factor apparatus which consist of 2 hoppers with trap door and a cylinder.

6.3 COMPRESSIVE STRENGTH

The test is conducted according to IS 516, to determine the compression strength. The quality is communicated in N/mm2. For cubical shape mould compression test is done. Size of cube is 150 x 150 x 150 mm, and size of the aggregate should not more than 20mm. The solid examples are by and large tried at ages 3 days, 7 days, 14days and 28days

6.4 SPLIT TENSILE STRENGTH TEST

The cylinders are kept over the loading platform of compressive testing machine and load applied progressively till the specimen gets failed. This strength is much fundamental with a specific end goal to opposes cracks developed in the concrete. Casted specimen is subjected to testing after the curing, test is done for 7 and 28days the tensile strength at which the failure occur is termed as tensile strength of concrete

6.5 FLEXURAL STRENGTH TEST

-Flexure strength test was conducted to test the beam of size 100x100x500mm.All the beams were tested by third point loading. This test is carried out to know the ability of the beam or slab to resisting the failure in bending. In the present work of study, the unreinforced concrete beams were tested. Usually flexural strength is minimum in the middle third portion of the beam. The test were conducted on a universal testing machine
Central load is acted here to beam to know flexural strength. Load is applied till failure occurs.

6.6 ACID ATTACK TEST

Concrete cubes of dimension 150 mmx 150 mmx 150mm are prepared. These cubes are cured in the curing tank for 28 days. Following 28 days of curing each of the specimen is removed, from water, then cubes are placed in air for two days for consistent weight. The weight is taken and the specimens are again inundated in 5% of hydrochloric acid solution (HCI) for 28days. The cubes are taken from curing and placed in outside for two days for drying to put on a steady weight, after drying changes in weight and compressive strength of cubes are noted.

6.7 WATER ABSORPTION TEST

The cubes of dimension 150 mmx 150 mm x I50mm are prepared and cured for 28 days. At that point they are put over a coarser wire mesh for one minute, in the wake of taking it out from curing tank, and water is evacuated by a damp cloth. Immediately its weighed. Then 24 hours' oven drying at 105^0C And Weighed.

6.8 SULPHATE ATTACK TEST

Concrete cubes are prepared ,then cured in the curing tank for 28 days . 28 days of curing is done with all the specimens, they are kept out of water and for attaining a consistent weight they are kept in atmosphere for 2days. The weight is taken and the specimens are again immersed in 5% of Sodium sulphate (NA_2SO_4) for 28days. The cubes are taken out and kept for 2 days in atmosphere for drying to gain a constant weight, after drying changes in weight and compressive strength of cubes are noted

6.9 REBOUND HAMMER

Rebound hammer consist of spring control hammer, a plunger. The plunger is pushed towards the surface of the specimen, the mass is being rebound from plunger and it withdraws against the compel of spring. The hammer impacts against the concrete and spring control mass rebounds, the rider is taken by hammer with it along guide scale the rider is kept in place by clicking the button and rebound number is observed

6.10 ULTRASONIC PULSE VELOCITY TEST

This test is done to get the nature of cement by UPVT strategy according to IS: 13311 (Part 1) – 1992. It is likewise non-ruinous test. This technique helps to calculating the time of ultrasonic pulse velocity going to the concrete. Relatively higher speed is recorded if the concrete quality is great such as, consistency, homogeneity and so on. Pulse velocity = Path length / Transit time

7. RESULTS AND DISCUSSION

TEST RESULTS ON FRESH AND HARDEN CONCRETE
7.1 DENSITY TEST / YIELD TEST

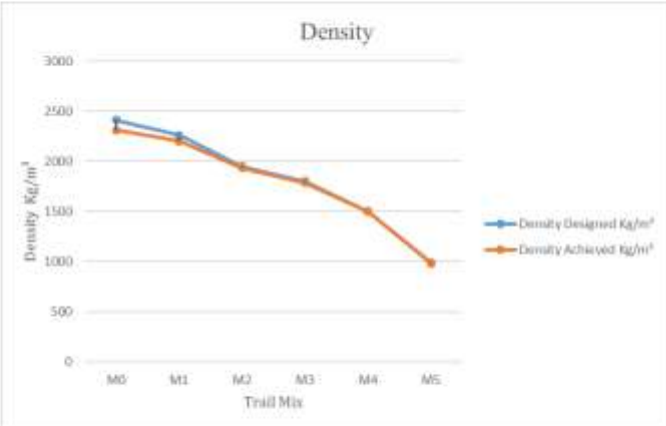


Fig 4.3: Density designed and Density achieved

The density results shown that normal mix has highest density and M5 mix having lower density, By increasing EPS beads there is a reduction of density.

7.2 COMPRESSIVE STRENGTH

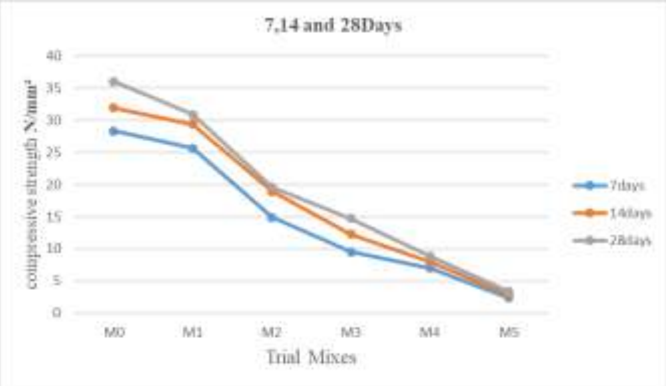


Fig 4.4 Compressive Strength Results for 7,14 and 28days

Compressive strength 7 days, 14 days and 28 days for different replacement of coarse aggregate with EPS Beads were carried out here M1 has a good compressive strength followed by M0 which is the normal mix. This pattern is same for 7,14 and 28 days. It is seen that as the coarse aggregate has been partially replaced by EPS Beads the strength decreases The highest value obtained when only 10% was used for partial replacement is for M1 mix with high density, since while doing partial replacement by EPS Beads for different time periods. There is no rise in the compressive strength, when partial substitution of coarse aggregate by EPS beads is done with respect to density.

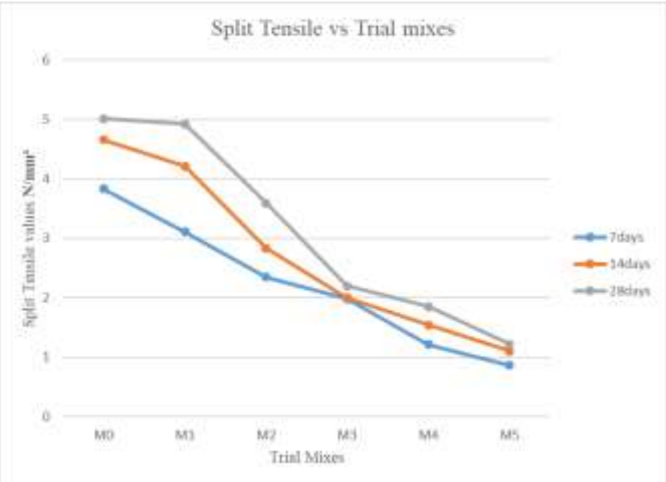


Fig 4.5 Split Tensile Strength Results for 7,14 and 28days of curing

7.3 SPLIT TENSILE STRENGTH

The split tensile strength results for 7days, 14days and 28days are given in table below. As shown in table and graph for control mix as got highest tensile strength. When only partial replacement of coarse aggregate with EPS beads is done. The value decreases with decreasing density of concrete. The split tensile strength get reduces with reducing the density of the concrete by increasing the usage of EPS beads.

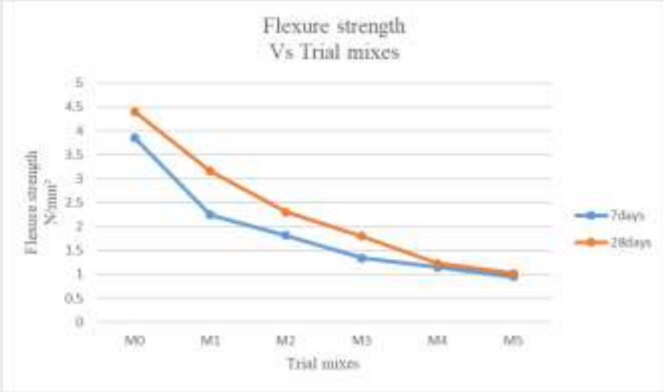


Fig 4.6 Flexure Strength Results for 7 and 28days of curing

From the 7 days and 28 days of curing the flexure test shall be carried out. The outcome from graph or table we find that normal mix is having highest flexural strength by partial and complete replacement for coarse aggregate with EPS beads the flexural strength get reduces by increasing the EPS beads in concrete.

7.4 WATER ABSORPTION

Table 4.7 Water absorption Result

Trial mix	Dry weight in grams (W_1)	Wet weight in grams (W_2)	Percentage of water absorption
M0	8.030	8.224	1.411
M1	7.780	7.890	1.414
M2	7.010	7.160	2.139
M3	6.430	6.580	2.332
M4	5.20	5.550	3.730
M5	3.460	3.620	4.624

The test is done on cubes made by partial and complete substitution of coarse aggregate with EPS beads the lowest water absorption noticed for normal trial mix i.e M0 the mix M5 with 77% of EPS beads with coarse aggregate which is having highest water absorption. By increased volume of EPS beads porosity is increases by decreasing the density of the concrete

7.5 SULPHATE ATTACK

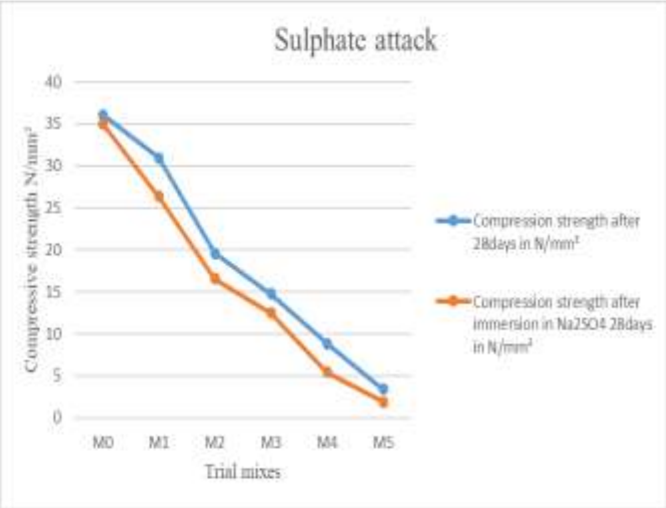


Fig 4.8 Sulphate Attack

Sulphate attack was done for the normal mix and mixes with partial replacement of cement coarse aggregate by eps beads compressive strength decreases as cubes comes in contact with the sodium sulphate the highest compressive strength was for the mix M1 with only 10% replacement of eps beads respectively.

7.6 ACID ATTACK

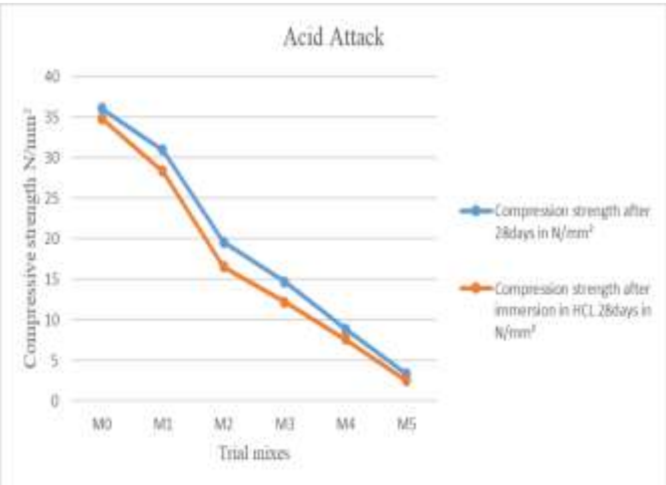


Fig 4.9 Acid Attack

Acid attack was only done for normal mix and mixes with partial substitution of coarse aggregate with eps beads here the test results noticed that the compressive strength decreases as specimen come in contact with the solution here highest compressive strength was for the mix with substitution of eps beads about 10% and below the compressive strength get reduces by increasing the substitution of eps beads

7.7 REBOUND HAMMER TEST

Table 4.10 Rebound Hammer Test Results

Mix	Rebound values for various mixes	Compressive strength from rebound test N/mm^2	Compressive strength by destructive test in N/mm^2
M0	34	35.5	36.5
M1	29	30.0	31.0
M2	18	19.6	20.2
M3	12	13.9	15.4
M4	8	8.6	9.5
M5	2	3.2	4.8

The rebound hammer results is similar to that of compression strength of concrete. Test was done on 28days curing. Control mix shows highest value, similarly considering 10% replacement having higher compressive strength with more density by substitution of EPS beads

7.8 ULTRASONIC PULSE VELOCITY TEST

Table 4.12 Ultrasonic Pulse Velocity Test Results

Mix	Method of probing	Travel path (L) in Km	Time in (T) in sec	Pulse velocity by cross probing V=(L/T) km/sec
M0	Direct	150	31.29	4.79
	Indirect	105	22.66	4.63
M1	Direct	150	35.75	4.28
	Indirect	105	24.39	4.34
M2	Direct	149.5	40.20	3.53
	Indirect	105	31.11	3.37
M3	Direct	148	47.65	3.10
	Indirect	105	34.24	3.08
M4	Direct	149.5	52.26	2.86
	Indirect	105	37.20	2.70
M5	Direct	148	55.75	2.64
	Indirect	105	40.32	2.59

It is the test done to find the quality of concrete as per homogeneity, segregation, cracks workmanship level and incidence or absence of internal flaws, here the results are found to be good concrete. For the good concrete the velocity criteria is 3.5-4.5 and excellent concrete it should be above 4.5 as per IS specification (IS: 13311, Part-1). Here M1 is best concrete without compromising with Density.

8. CONCLUSIONS

- As the density of concrete decreasing, the dead weight of structure also decreasing by replacing the polystyrene we can achieve light weight concrete.
- It is noticed that density will be decreases with compromising strength factor.

- As the percentage of replacing of polystyrene increasing strength also considerably decreasing compare to normal concrete.
- The compressive strength of the EPScrete increases with decrese in the replacements levels of the expanded polystyrene beads Polystyrene can replace up to 5% without alternating the strength of concrete considerably.
- Workability of the concrete is lesser than the normal mix In addition of partial replacement by EPS beads EPScrete can be produced with a less water/cement ratio than required without compromising the workability.
- Compaction factor is also less for the trial mixes compared to normal mix The strength of EPScrete decreases with increase in workability. i.e. with increasing water/cement ratio and polystyrene content.
- Density of the concrete will reduce at maximum extent is about 990Kg/m^3
- Decrease in strength and self-weight of the concrete by replacing EPS beads

9. FURTHER SCOPE

- Experiments can be done by changing different type of cement, manufactured sand and other cementitious materials with EPS Beads.
- The study can be done for different mixes.
- Introducing foaming agent.
- Fibers can also use to increases the strength of the concrete
- Air entering agents with artificial light weight aggregate can be used to achieve desire density and strength of the concrete

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