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“Effect Of Sawdust And Thermocol Beads As Partial Replacement Of Aggregate In Cement Concrete Blocks”

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ABSTRACT: Present development in the modern civilization has led to the increased industrial production to meet the needs of the people. The manufacturing and production of every product result in some waste end known as industrial waste. Sawdust is the by-product of cutting and grinding of wood. It is produced in very large quantity which can be better utilized in well planned manner. It can be utilized as a partial replacement of fine aggregate in manufacturing of blocks. EPS beads (thermocol) is the synthetic aromatic hydrocarbon polymer. It is usually white in color and made of expanded polystyrene beads. Its production is several million tons per year. Since its non-bio-degradable substance we cannot burn it or dump it. It will cause air pollution and soil pollution respectively. So, in this present study both sawdust and EPS beads are used in production of solid blocks which is cost effective, light weight as compared to regular solid blocks. The cost analysis is also done with normal cement concrete blocks, and it is found that sawdust & EPS beads based concrete blocks are 13.4% cheaper than normal concrete blocks.

Key words: Saw dust. EPS beads thermocol, Cement, CA, FA, Chemical admixture, Water.

1. Introduction

In developing country like India, construction act as backbone to boost economy. It directly increases country's Gross Domestic Products (GDP) and indirectly boost growth of other industries such as auto, agriculture, Information Technology (IT), Small and Medium Scale Enterprises (SMEs) and large-scale industries.

Sawdust has a variety of other practical uses, including serving as mulch, as an alternative to clay cat litter, or as a fuel. Until the advent of refrigeration, it was often used in icehouses to keep ice frozen during the summer. It has been used in artistic displays, and as scatter. It is also sometimes used to soak up liquid spills, allowing the spill to be easily collected or swept aside. As such, it was formerly common on barroom floors. Mixed with water and frozen, it forms a pyrite, a slow-melting, much stronger form of ice. Sawdust can be used as an alternative substitute for fine aggregate in concrete production. Before using the saw dust, it should be washed and cleaned because of large amount of barks are present which can affect setting time and heat of hydration of cement.

In this project, an attempt is made to make the concrete mix design as replacement to the concrete blocks with more benefits as high strength and low density. In this the partial replacement of coarse aggregate is done by Expanded Polystyrene (EPS) beads to reduce its density and partial replacement of fine aggregate is

done with sawdust. Sawdust is a by-product of cutting grinding and drilling of timber materials. It is composed of fine particles of wood. Certain animals, birds and insects which live in wood, such as carpenter ant are also responsible for producing the sawdust. Concrete produced after replacing fine aggregate with sawdust and coarse aggregate with EPS beads have better workability and full hydration of the cement which provide great bonding of the concrete. Sawdust concrete is light in weight and it has satisfactory heat insulation and fire resisting values.

The most important aspect and main target of the experiment are proving that sawdust-cement-gravel. Mixtures can prove to be more lightweight and cost efficient, along with use of EPS beads which reduces the density of concrete. Since sawdust and EPS beads are already waste then the cost would go down.

Need for Present Study

It's an era of construction, there is huge demand of building material such as cement, fine aggregate & coarse aggregate, resources are limited so we need to think over the alternatives of building materials. Also, every year in India sawdust production is about millions of tons. Burning of sawdust causes lungs problem, breathing problem, irritation in eyes etc. Such huge quantity needs to utilize in a planned and efficient manner so that it may not cause any disposal problem. EPS beads (thermocool) is used in medicine industry, packaging industry, logistic industry etc. It is non-biodegradable substance which cannot degrade after millions of years. It causes soil pollution if buried inside earth, causes air pollution if burned. So, efficient use of these EPS beads is necessary. Since EPS beads is very light in weight, we can use it for making light weight concrete blocks.

2. Brief Summary of Literature Review

Based on the above all literature review it is concluded that the Industrial waste obtained from sawdust refuse dump form timber shade & saw-mills, if used for partially replacing is and can reduce the density of block to a considerable extent. In framed structure the principle function of wall is that of cladding. Hence light weight blocks will reduce the dead load of masonry on beam, giving light section of beam and blocks thereby saving in construction material resources. Keeping this in view an experimental study has been carried out to test the performance of saw dust in cement sand create blocks. Effect of type of curing on compressive strength, density etc. have been carried out on various proportions of cement and ordinary sand partially replaced with varying % of saw dust by weight. For Timbercrete blocks after the experiment, the compressive strength for 5%, 10%, 15%, 20% and 25% blocks were recorded as .87N/mm², 8.48N/mm², 5.2N/mm², 3.78N/mm² and 2.66N/mm² respectively after 28 days. Expanded polystyrene waste in a granular form is used as lightweight aggregate to produce lightweight structural concrete with the unit weight varying from 1200 to 2000 kg/m³.

3. Objectives of the Present Study

- Using physical properties of all the ingredients, arrived the mix proportion of M20 grade concrete.
- Replacing fine aggregate by sawdust 5% constant and coarse aggregate by EPS beads with varying percentages such as 10%, 20%, 30% and 40% the workability of fresh concrete is determined.
- For the same concrete which is made of EPS beads & sawdust, used and casted a specimen of size 150 X 150 X 150 to determine - Compressive strength Water absorption Efflorescence
- The specimen of size 100 X 100 X 500 is casted to determine the flexural strength of concrete blocks made of sawdust and EPS beads
- Based on arrived results comparison made between cement concrete blocks and blocks made from sawdust and EPS beads.
- Analysing cost of EPS beads & Sawdust blocks with respect to other masonry units available in market with similar properties
- Find the optimum mix of EPS beads among the mixes considered, considering strength and durability aspects.

4. Characterization of materials

The constituents of a concrete under the present study are as follows:

1. Ordinary Portland Cement
2. Fine Aggregates
3. Coarse Aggregates
4. Water
5. Chemical Admixture
6. EPS beads (thermocool)
7. Sawdust

1. Cement

Physical Properties of Cement

Properties	Obtained Value	REQUIREMENT AS PER IS 1226 -1 87
Specific gravity	3.13	3.15
Standard consistency	32%	33%
Initial setting time	35 min ²	Not less than 30 min
Final Setting time	260 min	Not more than 600 min

2. Fine Aggregates

Fine Aggregate's Physical Properties

Properties	Obtained Value
Specific gravity	2.74
Grading zone	II

Sieve Analysis of Fine Aggregate

Is sieve	Weight retained in gram	%weight retained	Cumulative % retained	% of passing
4.75 mm	24	2.4	2.4	2.4
2.36 mm	51	5.1	5.1	5.1
1.18 mm	360	36	36	36
600 µm	204	20.4	20.4	20.4
300 µm	264	26.4	26.4	26.4
150 µm	68	6.8	6.8	6.8
Pan	2	2.	2.	2.
Σf			404.7	
Fineness of Modulus = Σf/100			4.047	
As per IS:383-1 70-Zone-II				

3.Coarse aggregate

These are basically crushed stones and are obtained from locally available quarries. These aggregates retain on 4.75mm IS sieve and restricted to a maximum size of 20 mm. They are strong, hard, durable and free from impurities and is as per IS 383: 1 70. The properties of the aggregates are as mentioned below

Physical Properties of coarse Aggregate

Properties	Result
Specific gravity	2.74
Fineness modulus	3.8

Sieve Analysis of coarse Aggregate

IS Sieve size	Weight Retained in gm	% of weight Retained	Cumulative % of Retained (f)	% of Passing F = 100-f
20 mm	22	5.84	5.84	4.16
12.5 mm	3687	73.74	7.58	20.42
10 mm	826	16.52	6.1	3.
4.75 mm	132	2.64	8.74	1.26
Pan	63	1.26	100	0

4.Water

Water is one more basic element of the concrete without which the fluidity cannot be imagined. The water to be used for curing and mixing of the concrete must be free from salts. Addition of excessive water to concrete than the design water cement ratio will lead to negative effects on strength of concrete. For higher grades of concrete, the water content should be less and to achieve that superplasticizers are used.



Pure tap water

5.Chemical Admixture

Master Glenium Sky 8233 superplasticizer is used in this work. It is manufactured by BASF construction chemical India Pvt. Ltd, Mumbai. It is intermixture of latest production on the basis of modified polycarboxylic ether. The product is developed for its applications in a high-performance concrete. Master Glenium Sky8233 is free of chloride & low alkali. It is well matched with all types of cement. It is basically a high range water reducer which reduces the water content without affecting the workability. The cement particles in general are very fine in state, having tendency to flocculate in presence of moisture. This flocculation entraps the water and therefore sufficient water will not be available to fluidify the mix. At this time addition of plasticizers cause them to get adhered to cement particles which in turn create repulsive forces between the particles which finally overcome the attractive forces. This process causes the cement particles to get deflocculated and it releases the water trapped inside it. Thus, it provides sufficient water to get homogeneous mixture.



Master Glenium 8233

6. Thermocol (EPS beads)

Thermocol is an Expanded polystyrene (EPS) which is a rigid and tough closed cell foam. It is usually white and made of pre-expanded polystyrene beads. It offers a non-hydroscopic, odorless, rigid, closed cell. Application is made possible because of Thermocol lightweight, water resistance, dimensional stability and inert nature. Polystyrene foams are good thermal insulators and are therefore often used as building insulation materials, such as in insulating concrete forms and structural insulated panel building systems

Polystyrene is a non-biodegradable material, so it creates disposal problems. Utilizing a crushed polystyrene in concrete is a good waste disposal method discarded polystyrene does not biodegrade for hundreds of years and is resistant to photolysis. Polystyrene foam blows in the wind and floats on water due to its specific gravity. It can have serious effects on the health of birds or marine animals. The polystyrene beads can be easily merged into mortar or concrete to produce lightweight concrete with a wide range of density. An application of a polystyrene concrete includes walls, cladding panels, tilt up a panel and a composite flooring. Polystyrene concrete was used to produce load bearing concrete wall, also as the material of construction for floating marine structures. The Expanded Polystyrene beads used in this research was spherical in shape and size varying between 1.18 to 2.36 mm in diameter.



EPS Beads

7.Sawdust

Sawdust is the waste material from the timber sawmills. Where the timbers are sawed for the specific purpose and the waste powder which extract from them is called sawdust. The small particles of wood or other material that fall from an object being sawed. Sawdust or wood dust is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool it is composed of fine particles of wood. The sawdust is acquired in abundance in tropical countries. This sawdust is used as fuel limitedly. The main method of disposal is by open burning method.



Sawdust

5.Mix Design Procedure (IS: 10262-200)

Concrete mix design is preferred to conventional mix proportion. The mix design is carried out as per IS10262-200, BIS and IS 456-2000 method.

Mix Design of M 20 Grade Concrete

- ☐ Grade designation: M20
- ☐ Type of cement: OPC 53 Grade confirming IS 1226
- ☐ Maximum nominal size of aggregate: 20 mm
- ☐ Minimum cement content: 320 kg/m³ (IS456-2000)
- ☐ Maximum water content ratio: 0.45 (Table 5 of IS 456-2000)
- ☐ Workability: 100mm (slump)
- ☐ Exposure condition: Severe
- ☐ Method of concrete placing: By manually
- ☐ Degree of supervision: Good
- ☐ Type of aggregate: Crushed angular aggregate
- ☐ Maximum cement content: 450 kg/m³
- ☐ Mineral admixture: Superplasticizer conforming to IS 103

TEST DATA FOR MATERIALS

- ☐ Cement used: OPC 53 Grade confirming IS 1226
- ☐ Specific gravity of cement: 3.13
- ☐ Specific gravity of thermocol beads (EPS beads): 0.011
- ☐ Specific gravity of sawdust: 2.15
- ☐ Specific gravity of: Coarse aggregate 20 mm: 2.74
- ☐ Fine aggregate: 2.74

[1] Water absorption:

Coarse aggregate: 0.5%,

Fine aggregate: 1.0%

[2] Free(surface)moisture:

Coarse aggregate: Nil (absorbed moisture also nil)

Fine aggregate: Nil

[3] Sieve analysis:

Coarse aggregate: Confirming to all in aggregate of Table 2 of IS 383

Fine aggregate: Confirming to grading zone ii of table 4 of IS 383

[4] Determination of Target Mean Strength for Proportioning

$$f_{ck}^{1} = f_{ck} + 1.65s$$

$s = 4$ (According to IS 10262–2009) for M20 grade

Therefore, target strength = $20 + 1.65 \times 4 = 26.6 \text{ N/mm}^2$

[5] Selection of Water Cement Ratio

Adopted maximum water cement ratio = 0.45

From the Table 5 of IS456-2000 maximum water cement ratio is 0.45 0.45=0.45 hence ok

[6] Selection of Water Quantity

From Table 2 of IS 10262-2009, maximum water content for 20 mm aggregate= 186 liters.

Estimated water content for 100mm slump = $186 + (6/100) \times 186 = 197$ liters.

Based on trials with superplasticizer water content reduction of 25% has been achieved.

Hence arrived water content = $197 \times 0.75 = 148$ liters.

[7] Calculation of Cement Content

Adopted water/cement ratio=0.45

Cement = $148/0.45 = 329$ kg/m³

From table 5 of IS 456, minimum cement content for 'Severe' exposure condition = 320 kg/m³.

$329 \text{ kg/m}^3 > 320 \text{ kg/m}^3$. Hence OK

[8] Coarse and Fine Aggregate Volume Proportion

For water-cement ratio of 0.50 = 0.62 (from table 3 IS 10262:2009 for Zone II 20mm aggregate size)

In the present case w/c = 0.45

Therefore, for w/c of 0.4 = 0.63 (w/c ratio decrease by 0.1 proportion increase by 0.02)

Therefore, Volume of Coarse aggregate = 0.63 m^3

Volume of Fine aggregate = $1 - 0.63 = 0.37 \text{ m}^3$

[9] Mix Calculation

a. Volume of concrete = **1 m³**

b. Volume of cement = $(\text{Mass of cement} / \text{Sp. gravity}) \times (1/1000) = (329/3.13) \times (1/1000)$
= 0.105 m³

c. Volume of water = $(\text{Mass of water} / \text{Sp. gravity}) \times (1/1000) = (148/1) \times (1/1000)$
= 0.148 m³

d. Volume of chemical admixture

(Superplasticizer @ 2.0% by mass of = $(\text{Mass of chemical admixture} / \text{Sp. gravity Cementitious Material of admixture}) \times (1/1000)$

$$= (6.58/1.145) \times (1/1000)$$

$$= \mathbf{0.0057 \text{ m}^3}$$

e. Volume of all in aggregate (e) = $[a - (b+c+d)]$
 = $[1 - (0.105 + 0.148 + 0.0057)]$

$$= \mathbf{0.741 \text{ m}^3}$$

f. Mass of coarse aggregate = e X volume of coarse aggregate X specific gravity of fine aggregate X 1000
 = $(0.741 \times 0.63 \times 2.74 \times 1000)$

$$= 1279.11 \text{ kg/m}^3$$

g. Mass of fine aggregate = $e \times \text{Volume of fine aggregate specific gravity of fine aggregate} \times 1000$

$$= (0.741 \times 0.37 \times 2.74 \times 1000)$$

$$= 751.22 \text{ kg/m}^3$$

Quantities for 1m³ of Concrete

Materials required	Weight kg/m ³
Cement	329
Water	148
Fine aggregate	751.22
Coarse aggregate	1279.11
Water cement ratio	0.45

Mix ratio = C: FA: CA: W/c

Mix ratio = 1:2.28:3.88:0.45

We are doing partial replacement of coarse aggregate with thermocol beads (EPS beads) and fine aggregate with sawdust on volume basis

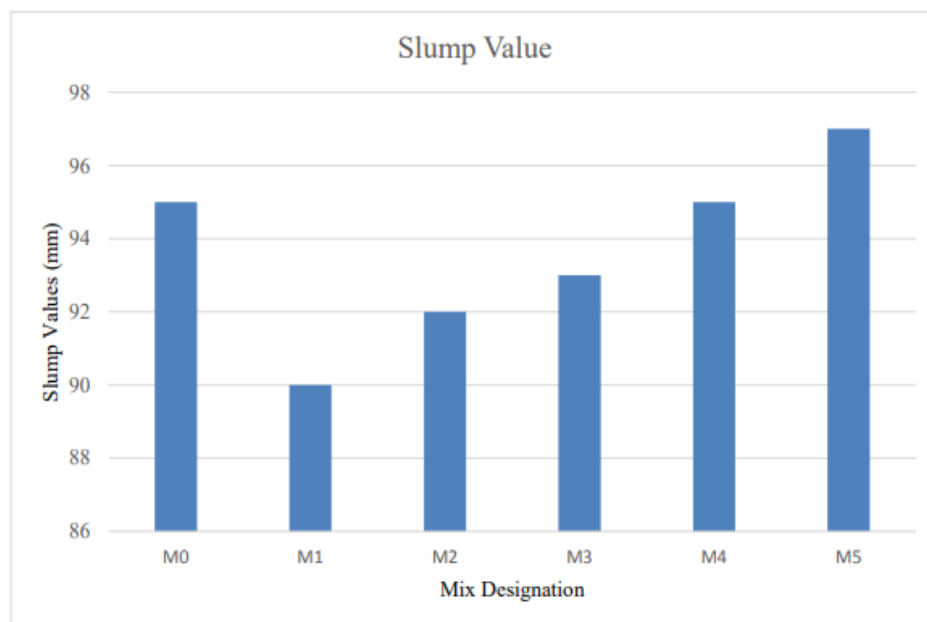
Mix Design for different mix designation

Mix Designation	Percentage replacement of Sawdust & EPS beads	Cement (kg/m ³)	Fine aggregate (kg/m ³)	Sawdust (kg/m ³)	Coarse aggregate (kg/m ³)	EPS beads (kg/m ³)
M0	0% + 0%	329	751.22	0	1279.11	0
M1	5% + 0%	329	713.66	29.47	1279.11	0
M2	5% + 10%	329	713.66	29.47	1151.19	0.512
M3	5% + 20%	329	713.66	29.47	1023.28	1.024
M4	5% + 30%	329	713.66	29.47	895.37	1.536
M5	5% + 40%	329	713.66	29.47	767.46	2.048

6.RESULTS

Workability Test

Slump Cone test was conducted for conventional concrete by replacing fine aggregate with 5% sawdust and coarse aggregate with 0%, 10%, 20%, 30% & 40% with EPS beads.



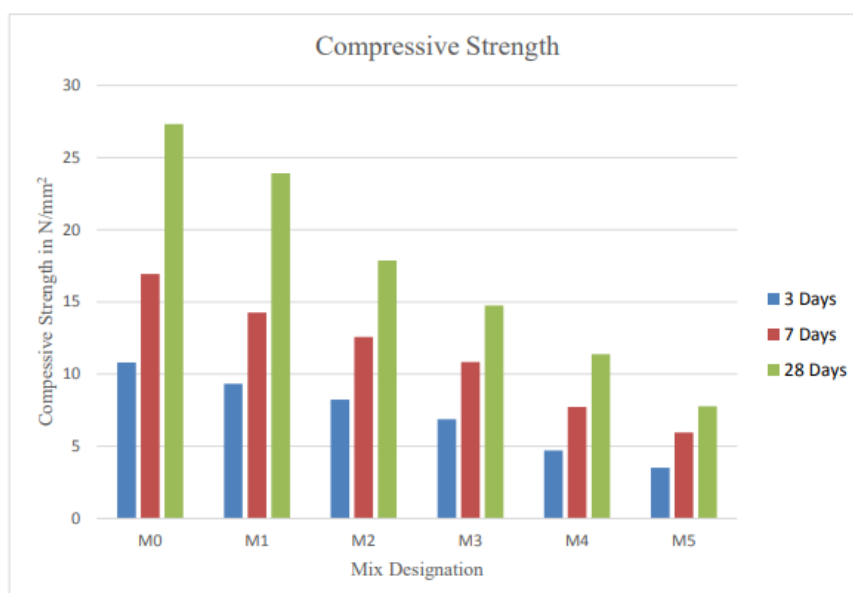
Slump Value Variation

Discussion on Workability

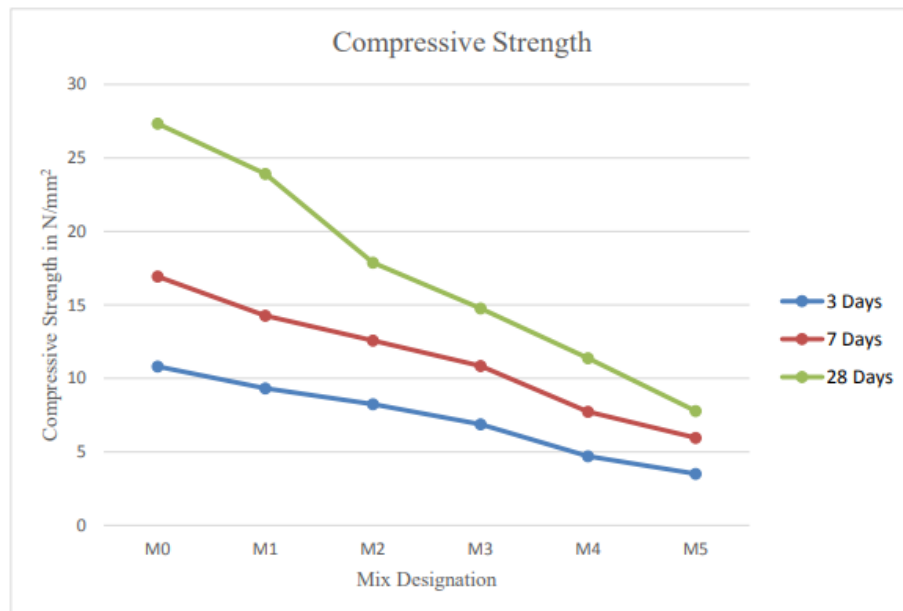
The slump was found to be in decreasing order with addition of Sawdust which affected the workability of concrete. Superplasticiser use to maintain the workability. The decrease in the value of slump may be due to the nature of sawdust which absorbs water. The slump was found to be increasing marginally with addition of EPS beads, due to spherical and smooth surface of EPS beads.

Compressive Strength Test

The compressive strength of sawdust & EPS beads concrete was determined at 3, 7 and 28 days of curing by considering the average of three specimens. It is the major test to determine the strength of blocks. This test is conducted at site in each batch of supply.



Bar Chart for Compressive Strength at 3, 7 & 28 days



Graphical Representation of Compressive Strength at 3, 7 & 28 days

7. Discussion on Compressive Strength Test Results

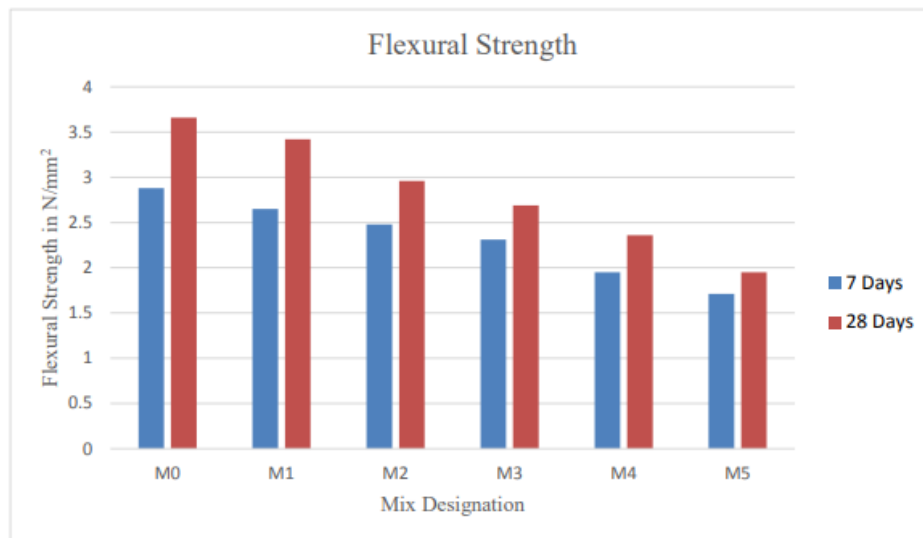
The compressive strength of concrete cube specimen made with and without sawdust and EPS beads are tested at 3 days, 7 days and 28 days of curing period.

The compressive strength of 'M1' mix i.e., 5% sawdust in place of fine aggregate is decreased by 12.51% compared to M0 due to low specific gravity of sawdust. Further, the addition of EPS beads with varying percentage, the compressive strength of concrete decreases gradually due to low specific gravity of EPS beads and less density of mix designate.

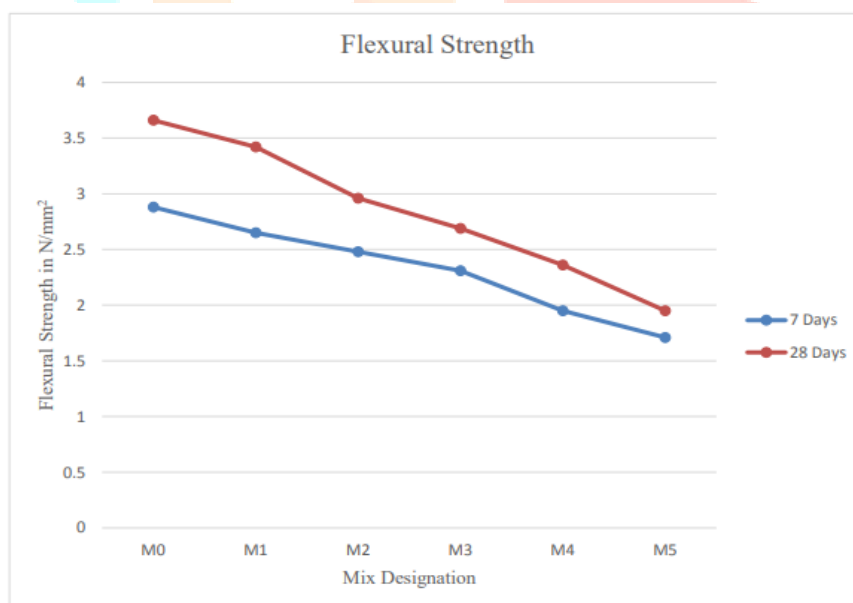
M5 mix shows 71.53% decrease in compressive strength compare to M0, but it is higher than the normal cement concrete blocks. Hence it can be used.

8. Flexural Strength Test

The Flexural strength of normal concrete and concrete with sawdust and EPS beads were determined for 7 and 28 days of curing by considering the average of three specimens. The beams were casted of standard size (100 × 100 × 500) mm and then tested in Universal Testing Machine.



Bar Chart for Flexural Strength at 7 & 28 days



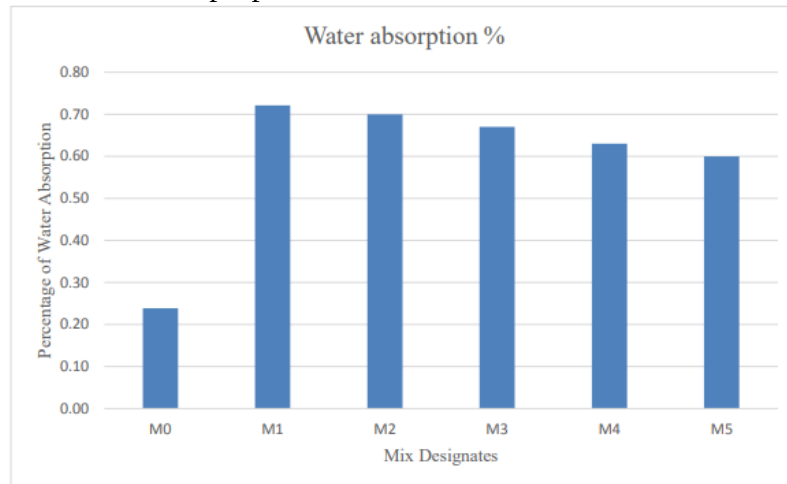
Graphical Representation of Flexural Strength at 7 & 28 days

Discussion on Flexural Strength

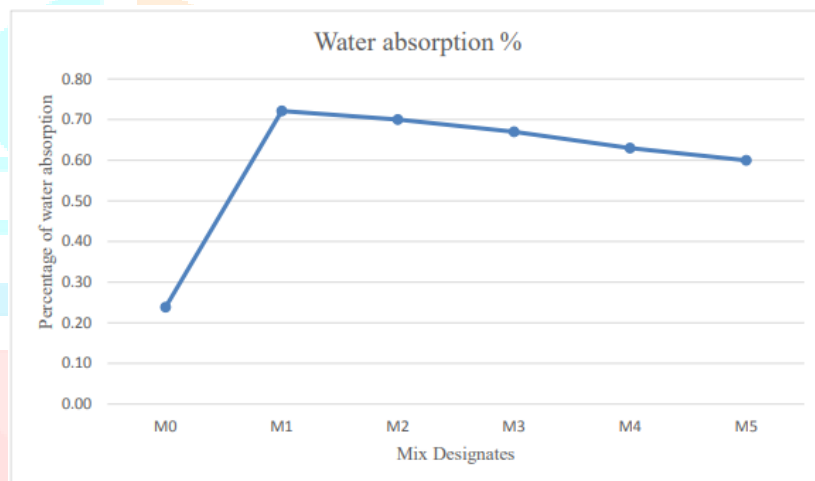
The flexural strength of concrete cube specimen made with and without sawdust and EPS beads are tested at 7 days and 28 days of curing period. The flexural strength of 'M1' mix i.e., 5% sawdust in place of fine aggregate is decreased by 6.56% compared to M0 due to low specific gravity of sawdust. Further, the addition of EPS beads with varying percentage, the flexural strength of concrete decreases gradually due to low specific gravity of EPS beads and less density of mix designate. M5 mix shows 46.72% decrease in flexural strength compare to M0, but it is higher than the normal cement concrete blocks. Hence it can be used.

9. Water Absorption Test

Water absorption test for different mix proportions of Sawdust and EPS beads blocks were carried



Bar chart for percentage of water absorption v/s mix designates



Graphical Representation of percentage of water absorption v/s mix designates

Discussion on Water Absorption Test

- It can be clearly seen that percentage of water absorption increases by addition of sawdust, after that no significant change is observed.
- Water absorption is maximum for M1 type mix, due to absorption of water by sawdust.
- While moving toward M2 to M5 water absorption decreases due to spherical shape and non-absorbing EPS beads

Efflorescence Test

The Efflorescence Test is carried as per IS 3495:1992. The efflorescence test is conducted and investigated for sawdust and EPS beads cubes, to find any salt deposits on surface of the cubes.

Discussion on Efflorescence Test

After conducting efflorescence test for each specimen of M1, M2, M3, M4 and M5 mix its surface is examined to find the deposits of salt layer presence. It's observed that, there is no presence or occurrence of salt layer on cubes surface after the evaporation of water from the dish. Hence its efflorescence test report is "nil", which states no presence of harmful salts or may be concluded that sulphates of sodium and magnesium are within the limits.

10. COST ANALYSIS OF SAWDUST AND EPS BEADS CONCRETE AS BLOCKS

Cost plays major role in construction. Generally required strength of block which are available in market are 4 N/mm^2 to 6 N/mm^2 . In this study following strength found for different designated grades.

Compressive Strength Variation as per Designated Grades

Designated Grades	Compressive Strength in N/mm^2
M ₀	27.33
M ₁	23.91
M ₂	17.87
M ₃	14.76
M ₄	11.38
M ₅	7.78

So, we chosen M5 mix designate.

Market price of materials used

Cost of Cement is ₹320.00 for 50kg. including GST is 28%

Cost of Fine aggregate is ₹750.00/MT. including GST is 5%

Cost of Coarse aggregate is ₹725.00/MT. including GST is 5%

Cost of Block having dimension 400mm X 200mm X 200mm is ₹62.00 including GST is 18%.

Cost Analysis of block

Cost of 1 Cum of Mix designate M5 Cement = $329 \times 6.4 = ₹2105.60$

Fine aggregate = $713.66 \times 0.75 = ₹535.2$

Coarse aggregate = $767.46 \times 0.725 = ₹556.4$

Total Cost = ₹3197.2

Volume of 1 block of size 400mm X 200mm X 200mm = 0.016 Cum Cost of 1 block

Material Cost = $3197.2 \times 0.016 = ₹51.1$ Other cost @ 5% = ₹2.55

Total Cost = ₹53.65 Therefore:

- ☐ Cost of normal blocks = ₹62.00
- ☐ Cost of Sawdust & EPS beads-based blocks = ₹53.65
- ☐ Difference = $₹(62.00 - 53.65) = ₹8.35$
- ☐ Difference % = $(8.35/62) \times 100 = 13.4 \%$

Cost Saving on 1 block = 13.4 %

CONCLUSION

The following points are concluded from the analysis of present study:

- Experimental investigation shows that maximum slump obtained for M5 mix, which is 97 mm and minimum slump obtained for M1 mix, which is 90 mm. Initially slump values gets decrease with addition of sawdust, again after addition of EPS beads it get increases gradually due to spherical shape and less specific gravity of EPS beads.
- Compressive strength decreases from M1 mix to M5 mix due to addition of sawdust and EPS beads. For M1 mix the compressive strength reduces by 12.51% as compared with M0 mix, due to low specific gravity of sawdust. Also, for M5 mix the compressive strength reduces by 71.53% as compared with M0 mix, due to very low specific gravity of EPS beads.
- Compressive strength of sawdust and EPS beads-based blocks are 7.78 N/mm^2 , while load bearing wall masonry unit is range from 7.0 N/mm^2 to 12 N/mm^2 , and non-load bearing wall masonry units are having compressive strength is in the range of 4 to 5 N/mm^2 . Hence sawdust and EPS beads-based blocks are easily replaced either as a load bearing or non-load bearing wall masonry units.
- Flexural strength decreases from M1 mix designate to M5 mix designate due to addition of sawdust and EPS beads. For M1 mix the flexural strength reduces by 6.56% as compared with M0 mix, due to low specific gravity of sawdust. Also, for M5 mix the flexural strength reduces by 46.72% as compared with M0

mix, due to very low specific gravity of EPS beads.

- Water absorption is maximum for M1 type mix, due to absorption of water by sawdust. While moving toward M2 to M5 water absorption decreases due to spherical shape and non-absorbing EPS beads.
- Efflorescence is found to be 'nil'. no deposit of soluble salt layer is noted.
- The weight of M5 mix i.e. sawdust 5% and EPS beads 40% based blocks are 14.5% less than normal concrete blocks which are available in market.
- The cost of sawdust and EPS beads blocks are 13.4% cheaper than other blocks, which are available in market.
- Better utilisation of sawdust can be seen, also EPS beads which are non-biodegradable utilised in proper manner which can reduces environmental pollution.

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