COMPARISON OF LIGHT WEIGHT CONCRETE WITH NORMAL MIX CONCRETE

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Abstract: A floating concrete structure is a solid body made of reinforced concrete and an inner chain of chambers filled with a lightweight impermeable material. In this technique, thermocole and pumice stone is used for preparation of the light weight concrete and density is reduced to attain the maximum efficiency, whereas the self weight of the structure is minimized thereby reducing the dead load on structure. The construction industry everywhere faces the problems and challenges. Two-third of the world surface is covered with water. It is therefore not surprising that there has been much activity with concrete in the sea in recent decades. The disadvantage of the conventional concrete is the high self weight concrete, where as the density is in the order of 2200 to 2600 Kg/m^3. In this technique the self weight of the concrete is reduce to attain the efficiency of the concrete as structural material. The light weight concrete has the density of 300 to 1850 Kg/m^3, it helps to reduce the dead weight of the structure. This Paper aims to discuss the development of Floating type of concrete by using lightweight aggregate (Pumice stone) and Foaming Chemical (Thermocole) and made the comparison of these two types of concrete mix with normal concrete mix.
Keywords: Floating concrete, Pumice Stone, Density, Compressive strength.

1. Introduction

The present day world is witnessing construction of very challenging and difficult civil engineering structures. Researchers all over the world are attempting to develop low density or lightweight concrete by using different admixtures in concrete up to certain proportions. This study deals with the development of Floating concrete by using Foaming chemical (Thermocol) and Pumice stone separately. In former the Cement slurry is made by Cement and water then this slurry is introduced to air so that when the mix sets and hardens, uniform cellular structure is formed. This is the mixture of cement-water and sand then thermocol is added to this slurry which gives the cellular structure and thus makes the concrete lighter than the conventional concrete. The foam is created using a foaming chemical, mixed with water and air from a generator. The foaming chemical used must be able to produce air bubbles with a high level of stability, resistant to the physical and chemical processes of mixing, placing and hardening. The chemical which we used for generating foam is Poly Carboxylate Ether. In the later Pumice is a lightweight

aggregate of low specific gravity. It is a highly porous material with a high water absorption percentage. In this we do not use the conventional aggregate and replace it by the pumice stone. Pumice is the specimen of highly porous rocks having density approximately 500-600 Kg/m3. Pumice is produced when super- heated, highly pressurized rock is violently ejected from volcano. Pumice comes in various sizes. The unusual foamy configuration of pumice happens because of simultaneous rapid cooling & rapid depressurization. Pumice has an average porosity of 60-80% and initially floats on water. While in normal concrete, aggregates are natural crushed stone having different properties than the light weight aggregates.

2. Materials and Properties

The materials used for the preparation of floating concrete are Cement, sand, water, pumice stone and thermocole. These materials and their properties are discussed below:

A. Cement

Cement is the material that has cohesive and adhesive properties in the presence of water. Such cements are called hydraulic cements. These consist primarily of silicates and aluminates of lime obtained from limestone and clay. Ordinary/Normal Portland cement is one of the most widely used type of Portland Cement. The name Portland cement was given by Joseph Aspdin in 1824 due to its similarity in colour and its quality when it hardens like Portland stone. Portland stone is white grey limestone in island of Portland.

(a) *Composition of Ordinary Portland cement*

The chief chemical components of ordinary Portland cement are

- Calcium
- Silica
- Alumina
- Iron

The chief compound which usually form in process of mixing:

- Triclcium silicate (3CaO.SiO2)
- Dicalcium silicate (2CaO.SiO2)
- Tricalcium aluminates (3CaO.Al2O3)
- Tetracalcium aluminoferrite (4CaO.Al2O3.Fe2O3).

B. Aggregate

Aggregate properties greatly influence the behavior concrete since they occupy 80% of the total volume of concrete. The aggregates are classified as Fine Aggregate & Coarse Aggregate

Those particles passing the 9.5 mm sieve, almost entirely passing 4.75 mm (No.4) sieve, and predominantly retained on the 75 µm

(No. 200) sieve are called fine aggregate. Those particles that are predominantly retained on the 4.75 mm (No. 4) sieve, are called coarse aggregate. But in our study we have replaced the coarse aggregate with pumice stone and thermocol to get the required floating density.

C. 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. Hydration is a chemical reaction in which the major compounds in cement form chemical bonds with water molecules and become hydrates or hydration products. Details of the hydration process are explored in the next section. The water needs to be pure in order to prevent side reactions from occurring which may weaken the concrete or otherwise interfere with the hydration process. The role of water is important because the water to cement ratio is the most critical factor in the production of "perfect" concrete. Too much water reduces concrete strength, while too little will make the concrete unworkable. Concrete needs to be workable so that it may be consolidated and shaped into different forms (i.e.. walls, domes, etc.). Because concrete must be both strong and workable, a careful balance of the cement to water ratio is required when making concrete.

D. Pumice Stone

Pumice is a type of volcanic rock formed when lava with extremely high levels of water and gases is violently ejected from a volcano. As explained by the Mineral Information Institute, when the gases escape, the rock become "frothy." Once the rock hardens, the result is a very light, buoyant material. The main use of pumice is for making lightweight construction materials such as concrete. Pumice has a chemical composition similar to that of obsidian, or volcanic glass. It has very thin, translucent bubble walls of extrusive igneous rock. Pumice stones as used in beauty salons are generally high in silica and low in iron and magnesium.

E. Thermocole

Thermocole or Expanded Polystyrene (EPS) is a preferred packaging material across many industrial segments. Widely accessible for purchase from any part of the country. It is one of the most reliable and cost- effective means to protect your goods from transit damage. Thermocole is extremely light. It can be moulded into any desired shape and is yet sufficiently rigid to absorb shocks and physical impact. The density of the thermocole is too less compare to the aggregate, hence it satisfy the floating property.

3. Research Objectives & Focus

The main research objective was to first develop the light weight concrete using Pumice stone & Thermocol and to reduce the self weight of the structures and then to compare light weight concrete using pumice stone and thermocol with normal concrete. This comparison will be helpful in understanding the behavior of light weight and floating concrete. The present day world is witnessing construction of very challenging and difficult civil engineering structures. Researchers all over the world are attempting to develop low density or lightweight concrete by using different admixtures in concrete up to certain proportions. This study deals with the development of Floating concrete by using Foaming chemical (Thermocol) and Pumice stone separately.

3.1 Research Significances

- Constructions over water bodies.
- Used as an acoustic medium
- Low thermal conductivity
- Oil exploration and drilling platforms,
- Oil production platforms,
- Floating docks,
- Floating gates for dry docks,
- Floating airports,
- Floating power stations
- Floating hotels
- Floating shopping centres
- Floating industrial plants,
- Floating bridges
- Floating bridges piers
- Floating lighthouses
- Floating bridge girders.

This is a convenient place to summarize again the advantages of floating concrete structures.

1. Durability and low maintenance.
2. Excellent high resistance to compressive forces.
3. Excellent behavior in cold weather and at low temperatures.
4. Good thermal insulating properties
5. High fire resistance,
6. Utilization of mainly local materials,
7. Economy.

4. Experimental Work

To study the floating property of the Light weight concrete:

4.1 Materials used.

Cement – Portland Pozzolona cement

The Ordinary Port Cement (OPC) was classified into three grades namely 33 grade, 43 grade and 53 grade depending upon the strength of cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33 N/mm2, it is called 33 grade cement, If the 28 days strength is not less than 43 N/mm2, it is called 43 grade cement, If the 28 days strength is not less than 53 N/mm2, it is called 53 grade cement.

The chemical compositions of different properties are given below:

Specific Gravity	2.57
Water absorption	0.57%
Fineness Modulus	2.39

Specific Gravity	2.74
Initial setting time(min)	30
Final setting time(min)	262

Properties of OPC Aggregate:
Pumice Stone (size 10mm-20mm)

Specific Gravity	1.13
Desnity (g/cm3)	0.25
Size (mm)	10-20

Properties of Pumice Stone Fine Aggregate
In this study I used the sand of zone -11, known from the sieve analysis using different sieve sizes (10mm, 4.75mm, 2.36mm,1.18mm, 600µ,300 µ,150 µ) adopting IS 383: 1963.
Properties of Sand ***Other properties*** Aluminum Powder Water – Tap water
Mixed Procedure – Mixer mixing Compaction – Table Vibration
Curing practice - Moist curing by pounding Cube size – 15cm×15cm×15cm
Testing of cubes – Compressive test after 28 days

4.2 Experimental Procedure

- We have casted two types of samples slab and cube
- The purpose of casting slab is to find whether the slab float or not and to find out how many Kg of weight it can carry.
- The purpose of casting cube is to find the compressive strength
- The purpose of casting cube is to find the compressive strength
- Next thermocol balls mixed with cement (OPC 43 grade) and with suitable water cement ratio.
- Cast it into slab and cube
- After 24hours demould it, cure it and test the specimen.

4.3 Test Specimen

Cube (150 mm * 150 mm * 150 mm)
Slab (500 mm * 300 mm * 50 mm)

Testing of materials: Cement
Standard Consistency test:
The standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger to penetrate to a point 5 to 7mm from the bottom of the vicat mould.
Weight of cement = 300g Amount of water = 102g.
It is given as weight of (water/weight of cement) x 100 and it came out as 34%.
Fineness Test:
Data:-
Weight of cement taken (A) =100 gm
Weight of cement retained on 90µ I.S. Sieve (B) = 05 gm.
Calculation:-
Fineness = (B/A) × 100
= 05%
I.S. requirement for fineness = less than 10%
Fineness value is less than 10%.
Hence it could be be used in this study.

Setting Time:
Weight of cement = 300 gm.
Water content = 0.85 P. Where P = Standard Consistency
= 0.85 × 34%
= 28.9% of cement
= (28.9÷100) ×300gm
= 86.7 gm = 86.7 ml.

***Initial Setting Time*:**
Initial setting time = 40 minutes
I.S. requirement = more than 30 (as per I.S 4031-1968)
Final Setting time:
When the test block has attend such hardness that the needle does not pierce through the block more than 0.5 mm, that time is known as final setting time. I.S. requirement = less than 600 minutes (as per I.S. 4031- 1968).
Tests on a light weight aggregates (Pumice Stone):
For this study, we got pumice stone as big as 55 mm size. So we crushed it to the size of 20 mm & less. The mix design for the first

sample is decided based on the studies, and then further samples were made by changing some proportions in previous ones.

5. Observations and Calculation for Pumic Stone samples

Sample1: 3 cubes
Cement: 8 kg Crushed sand: 12 kg
Pumice stone (< 20 mm):24kg Water: 4.8 kg W/C=0.6
Admixture: Aluminum powder 2%.

TABLE 5.1 RESULTS: After 3 days of cube testing.

Sample No	Wt (Kg)	Density (kg/m3)	Avg. Density(kg/m3)	Load (KN)	Strength (N/mm2)	Avg. comp. Strength (N/mm2)
1	5.85	1733.34		249	11.07	
2	5.90	1748.14	1748.14	270	12.005	11.98
3	5.95	1762.96		290	12.89	

Sample2: 3 cubes
Cement: 5 kg Crushed sand: 7.5 kg
Pumice stone (< 20 mm):15kg Water: 2.5kg W/C=0.5
Admixture: Aluminum powder 2%.

TABLE 5.2 RESULTS: After 7 days of cube testing

Sample No	Wt (Kg)	Density (kg/m3)	Avg. Density (kg/ m3)	Load (KN)	Strength (N/mm2)	Avg. comp. Strength (N/mm2)
1	4.90	1451.85		265	11.77	
2	4.95	1466.67	1451.85	290	12.88	11.69
3	4.85	1437.03		235	10.44	

Sample3: 3 cubes
Cement: 4 kg Crushed sand: 6 kg
Pumice stone (< 20 mm):12 kg Water:1.6 kg W/C=0.4
Admixture: Aluminum powder 2%.

TABLE 5.3 RESULTS: After 21 days of cube testing

Sample No	Wt (Kg)	Densit (kg/m3)	Avg. Density (kg/m3)	Load (KN)	Strength (N/mm2)	Avg. comp. Strength (N/mm2)
1	4.20	1244.45		190	8.44	
2	4.30	1274.07	1244.45	200	8.88	8.29
3	4.10	1214.81		170	7.55	

Sample4: 3 cubes
Cement:6 kg Crushed sand:4.5kg
Pumice stone (< 20 mm): 9 kg
Water:1kg
Admixture: Aluminum powder 2%.

TABLE 5.4 RESULTS: After 28 days of cube testing

Sample No	Wt (Kg)	Densit (kg/m3)	Avg. Density (kg/m3)	Load (KN)	Strength (N/mm2)	Avg. comp. Strength (N/mm2)
1	3.20	948.14		68	3.022	
2	3.27	968.88	964.94	71	3.155	3.155
3	3.30	977.78		74	3.288	

6. Experiment on Light Weight Concrete using Foam Chemical (Thermocol)

Properties of Thermocole are:

- Low density,
- Low conductivity,
- Floating,
- Acoustic.

Table 6.1 Calculation (strength)

S.No	Parameters	CLC blocks	CLC blocks
01	DRY DENSIT Y (Kg/m3)	1200	1400
02	Compress ive Strength (N/mm2)	6.5	12.0
03	Drying Shrinkage (mm/m)	No shrinka ge	No Shrinka ge
04	Thermal conductiv ity (w/m.k)	0.37	.35

7.Observation and calculation for normal mix concrete cubes

Cement: 3.9kg
Fine aggregate: 6.78kg
Coarse aggregate: 13.41kg
Water: 2.025kg
Admixture: Aluminum powder 2%

TABLE 7.1 Results: After 3 days of cube testing

S.No	Wt (kg)	Density (kg/m^3)	Avg. Density (kg/m^3)	Load (KN)	Strength N/mm^2	Avg. comp. strength N/mm^2
1.	8.220	2435.55		370	16.44	
2.	8.450	2503.70	2482.95	358	15.91	15.03
3.	8.470	2509.62		305	13.55	

TABLE 7.2 Results: After 7 days of cube testing

S.No	Wt (kg)	Density (kg/m³)	Avg. Density (kg/m³)	Load (KN)	Strength N/mm²	Avg. comp. strength N/mm²
1.	8.220	2435.55		406	18.04	
2.	8.300	2468.14	2467.15	410	18.22	18.20
3.	8.430	2497.77		413	18.35	

TABLE 7.3 Results: After 21 days of cube testing

S.No	Wt (kg)	Density (kg/m³)	Avg. Density (kg/m³)	Load (KN)	Strength N/mm²	Avg. comp. strength N/mm²
1.	8.220	2435.55		420	18.66	
2.	8.440	2500.74	2484.9	430	19.11	19.03
3.	8.500	2518.51		435	19.33	

TABLE 7.4 Results: After 28 days of cube testing

S.No	Wt (kg)	Density (kg/m³)	Avg. Density (kg/m³)	Load (KN)	Strength N/mm²	Avg. comp. strength N/mm²
1.	8.340	2471.11		480	21.33	
2.	8.400	2488.88	2487.89	498	22.13	22.19
3.	8.450	2503.70		520	23.11	

8. Results

Sample1 gives average compressive strength 11.98 N/mm2, which is good for lightweight concrete. Also it gives average density 1748.14 kg/m3, but we have to reduce the density of concrete to nearly equals to density of water, so it is to be required that reduce the quantity of crush sand and that's why we reduced the quantity of crushed sand and also replaced it with pumice sand passing through IS sieve of size 4.75 mm. in next sample. Also we used two fractions of Aggregate i.e. M1 (10mm to 20 mm) and M2 (4.75 mm to10 mm).

Fig 8.1 Cube Sample irregular and unfinished edges.

Sample 2 gives the improved results having average density 1451.85 kg/m3 and average compressive strength 11.69 N/mm2, but average density of concrete is not nearly equals to the density of water. Also the quantity of cement is high, so we discussed this situation with our guide. He told us that if you reduce the quantity of cement it will help us to reduce the density as well as to achieve economy. Therefore in next sample we reduced the cement quantity and increased the pumice sand.

Fig 8.2 Cube with density more than density of water, hence it sinks

Fig 8.3 Slab floats on water

Sample3 gives the improved results having average density 1244.45kg/m3 and average compressive strength 8.29 N/mm2. We reduced the quantity of cement in this sample, but average density of concrete is still not nearly equals to the density of water. Therefore in next sample we again reduced the cement quantity and increased the pumice sand.

Fig 8.4 cube floats on water

Sample 4 gives lightweight concrete having surface flat & smooth and showing a good finish. Its average density 964.94 kg/m^3 and average compressive strength 3.1551 N/mm2. From the above results it seems that the compressive strength is decreased even if the density is nearly same as the previous sample.so this sample is perfect for the mix proportion.

9. Discussion

By comparing light weight concrete with normal concrete it seems their compressive strengths and densities are influenced by type of coarse aggregates. In normal concrete coarse aggregates are typically natural crushed stone, whereas lightweight aggregates are pumice stones. Although concrete compressive strength is generally related to the compressive strength of the coarse aggregates. Normal concrete is strong in compression but weak in tension, despite the decrease in weight of concrete mix by using light weight aggregates, it was seen that they also tent to decrease in compressive strength thus owing to advantages as well disadvantages. Pumice aggregate has low compressive strength and low density than the normal aggregate (crushed stone). Light weight concrete has an in-place density of the order of 1440 to 1840 kg/m3 compared to normal concrete with a density range of 2240 to 2400kg/m3. The main specialties of light weight concrete are its low density and low thermal conductivity

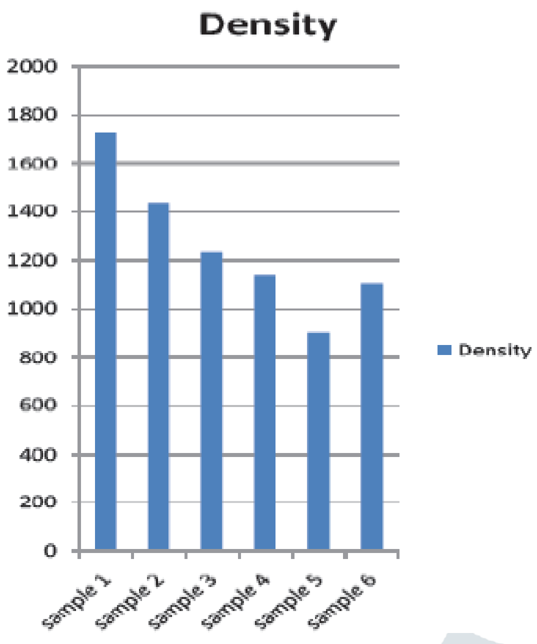

Fig 9.1 Variation of Densities with different w/c ratio

10. Conclusion

In this study, the influences of aggregate types and the amount on the compressive strength of concrete were investigated. Using different aggregate proportions (pumice) and five different lightweight concrete mixtures were produced with a satisfied strength. The result of the investigation showed that aggregate size and proportion influenced the unit weight and compressive strength of concrete. Moreover, the result showed that it is possible to produce a Floating and satisfied strength concrete by using pumice & Foam aggregate. It was also seen that, using light weight aggregate in the concrete mixture can reduce the dead load but decreases the concrete strength. From cost analysis it is proved that the cost of our project is less than that of brick masonry. The study showed that using pumice aggregate as a commixture enable to produce different strength grade lightweight concrete with different unit weight. These concrete does not satisfies the strength requirements for load bearing structural elements. . In this study only strength and unit weight were considered, other properties including carbonation and drying shrinkage, thermal conductivity and sound insulation properties can be investigated as a further study.

Floating concrete can be effectively used for building structures such as slabs, barges, buildings etc. Since maximum portion of earth is covered with water, it minimizes the consumption of land for construction works & this is an environment friendly method of construction of boats replacing wood & metals.

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