Floating Concrete to Solve Land Crises

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Abstract - *With rapid increase in population in India there is a growing demand in construction, but lack of land has led to increase in land prices. To suffice the land requirement an idea of creating floating concrete islands is presented. Seven new mixes of floating concrete have been developed; each have a different densities under 1000 kg/m³. A scaled model of a platform has been created for testing and demonstration of the idea of floating islands. During the creation of the different mixes various factors like chemical reaction, w/c ratio, materials (properties), density, porosity, durability, etc. are taken into consideration. Different light weight aggregates are used with cement, fly ash, glass fibers and different air entraining agents. Concrete mixes having densities ranging from 700 kg/m³- 1000 kg/m³ have been developed. The concrete can achieve higher strength allowing us to use this low-density concrete in structural components which would reduce the amount of raw material usage and reduce the dead load of the structure.*

Key Words: **Floating, Concrete, Density, Perlite, lightweight, dead-load.**

1. INTRODUCTION

Floating concrete is a lightweight concrete having a density of less than 1000 kg/m^3. Conventional concrete has a density of around 2400 kg/m^3. Floating concrete is made up of a mixture of cement, fly ash, light weight aggregates and admixtures.

The floating concrete can have a density ranging between 500 kg/m^3 to 1000 kg/m^3. Its lightweight property is suitable for use in non-load bearing walls and can also be used for thermal insulation, sound insulation and product making for now.

There is a need for a material which is more durable and whose usage reduces the threat to the environment. The "Floating concrete" with density lesser than 1000 kg/m^3 meets the requirements to replace materials such as wood or any other similar materials for these requirements.

Floating concrete can be achieved by: -

1.1 By replacing the usual mineral aggregate by light-weight aggregate [1]

Lightweight concrete can be achieved by using light weight aggregates to replace the commonly used aggregates. Light weight aggregates such as pumice, perlite, vermiculite., have been used for achieving light weight concrete.

1.2 By introducing gas or air bubbles in mortar (Aerated concrete) [1]

Aerated concrete is a low-density concrete which is produced by inserting air or gas into a cement-based mortar. This can be achieved using foaming agents or using aluminium powder and heating it. This would also result in a negative effect of lower strength.

2. OBJECTIVE

The objectives of this project are:

- To replace low density materials such as wood have been used in applications where the structure must float (such as in the building of boat houses, canoes, etc.)
- To reduce the self-weight of the concrete and concrete structures.
- To experiment with the materials required to develop floating concrete.
- The floating concrete should be durable and water resistant without applying an outer coating.
- To develop different mixes for floating concrete based on trials.
- To compare compressive strength of developed mixes and find the best mix.

3. METHODOLOGY AND MATERIALS.

This topic contains physical properties of various materials used throughout the experimental work and the procedure adopted based on the factors that will affect the properties of concrete.

3.1 MATERIALS USED

1-Cement

A cement is a binder, a substance used in construction that sets and hardens and can bind other materials together.

Concrete- which is a combination of cement and aggregate to form a strong building material. [1]

2-fly ash

Fly ash also acts as a binder and is used to replace cement, it provides better strength and finish in concrete

3- Perlite

It is a natural material found in volcanic regions. It is used to replace aggregates in concrete as it has a density of 1100 kg/m3. It is used to make light weight concrete.

4- Thermocol

It is a replacement for aggregates as it is very light in weight having a density of 16 kg/m3.

5- Foaming agent

Foaming agent is mixed with water which introduces air voids when mixed with concrete thus reducing its density.[4]

6- Waterproofing agent

Waterproofing agent provides a membrane so that water does not penetrate the concrete.

7- Aluminium powder

Aluminium powder when mixed with concrete it reacts with cement to produce hydrogen gas which forms voids in the concrete thus reducing its density.

8- Glass fiber

A glass fiber net or glass fibers are used in the mix to increase its tensile strength and also to provide reinforcement.

3.2 FACTORS OF CONSIDERATION

1- Chemical reaction

After casting the reactions start to take place and as time passes more hydration of cement takes place.

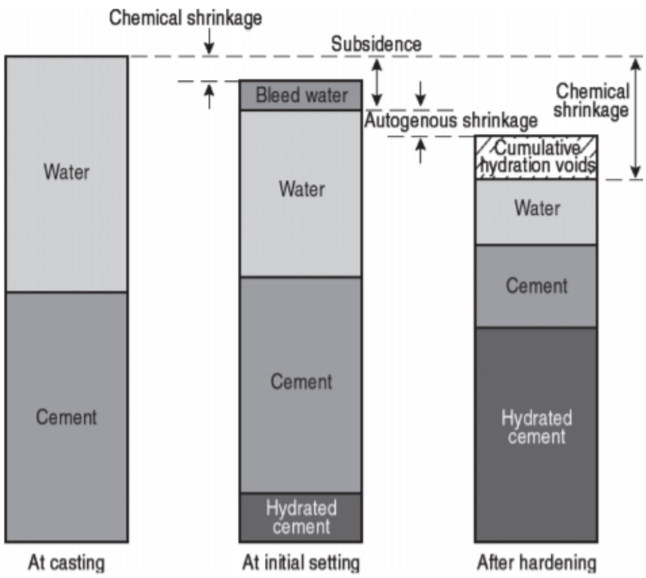

Figure 1: Concrete composition with time [5]

At first there might be inter-connecting voids but as time passes the cement hydrates making a layer between voids and also this layer might be very thin initially and so the sample or product should not be disturbed or moved as it might cause microscopic cracks that might lead to inter-connected voids.

The graph below shows how the strength increases with time.

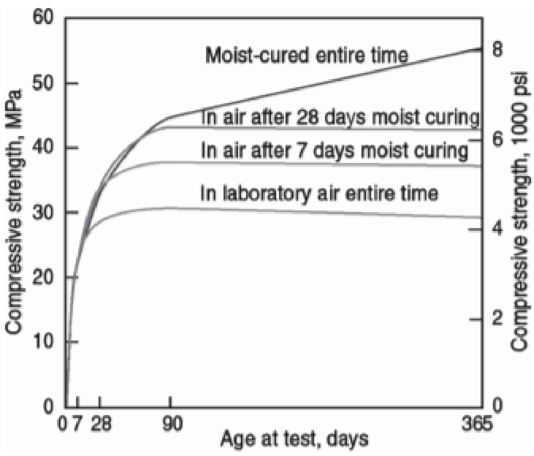

Figure 2: Compressive strength with time [5]

2- W/C Ratio

A misconception has been assumed by many that only 0.2 w/c is required for hydration of cement, but research has proved that water is also required for the gel pours if these pours are not filled the C-S-H gel production also stops reducing the strength of concrete. So the minimum w/c ratio should be 0.4. [6]

The compressive strength decreases with increase in w/c ratio and for floating concrete, strength is one of the main properties so least amount of water should be used but the concrete should also be workable.

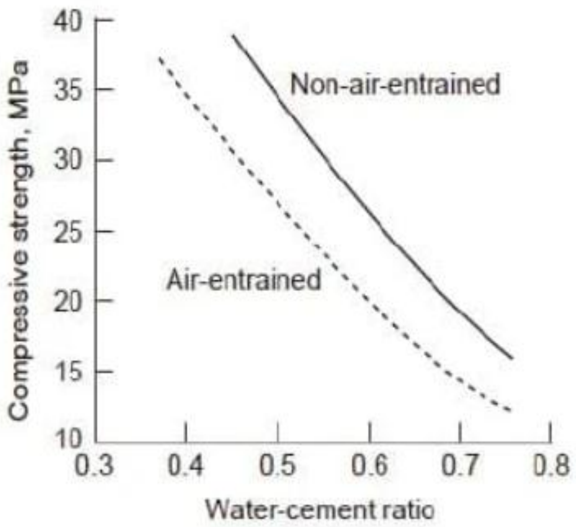

Figure 3: Effect of w/c ratio on compressive strength. [5]

3- Density

The initial density (24hr) of concrete is less than the final density (28 days) of concrete, it is due to: -

- Hydration of cement as time passes
- Shrinkage of concrete

So, this factor has to be taken under consideration when a mix is designed for floating concrete, if the initial density is just a little less than 1000 Kg/m3 but as time passes the density reaches above 1000 Kg/m3due to shrinkage which would cause the concrete not to float anymore.

4- Internal curing

Most lightweight aggregates absorb water, and thus more water is required but it also helps in internal curing of the concrete.

In floating concrete due to this perlite has been used as it does not absorb as much as other light weight aggregates, so it does it helps in internal curing of concrete but does not increase the density very much.

5- Durability

Having thin layers between the voids great care should be taken for the initial 7 days so no microscopic cracks are created. Floating concrete being porous is resistive to freezing and thawing.

6- Porosity

The porosity in the concrete decreases as hydration of cement progresses. At complete hydration the paste will have a certain amount of porosity as a result of excess water. At very low overall porosities, the hardened material has a closed pore structure, the pores are not interconnected. At higher porosities, the pores become inter-connected and form an open pore structure. The degree of porosity thus influences concrete permeability.

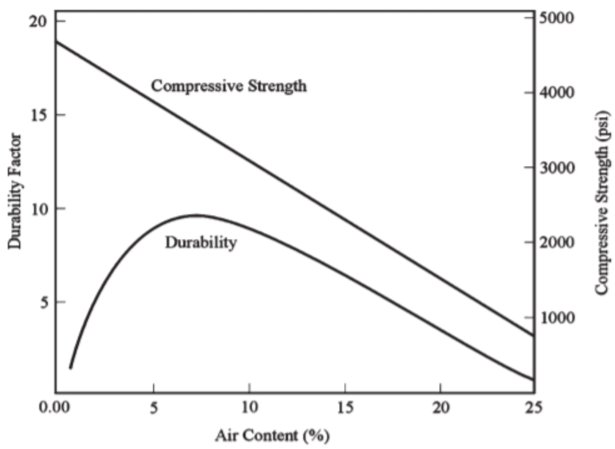

Figure 4: Effect of air content on compressive strength and durability [5]

Research shows that a loss of 5% in compressive strength of concrete occurs when1% by volume of entrained air is introduced in the concrete.

Figure 5: Fresh concrete showing air bubbles that are created due to foaming agent

Due to this the porosity must be kept at a level where max porosity can be achieved without inter-connecting voids.

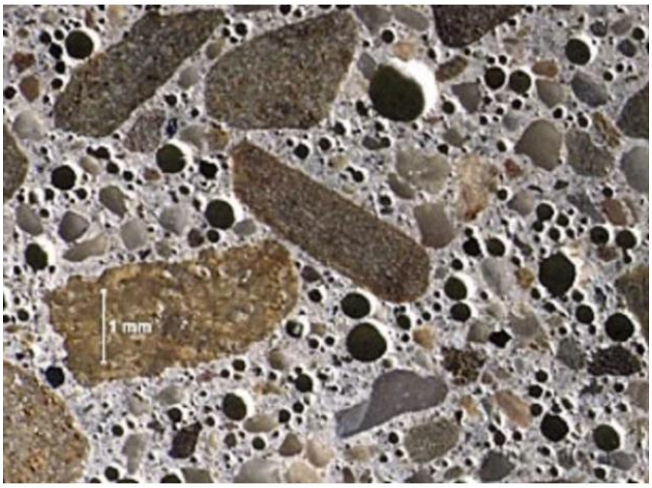

Figure 6: Microscopic view of concrete with air voids [5]

Due to the foaming agent the porosity increases and so after casting the compaction done should be minimum. The most important part in the mix is the mixing of foaming agent and the amount used.

3.3 MIX DESIGN

More than 30 different trials were done out of which 7 trials were successful.

Table 1: Different raw materials used for trials.

Raw Materials	Trial no.						
	21	22	24	28	29	30	32
Cement	✔	✔	✔	✔	✔	✔	✔
Flyash	✔	✔			✔		✔
Perlite	✔		✔		✔	✔	✔
Vermiculite		✔					
Aluminum				✔	✔		
Foaming agent	✔	✔	✔			✔	✔
Reinforcement							✔
Glass fiber							✔
W.P. agent	✔	✔			✔	✔	✔

(Refer table 5 for final mix design.)

Figure 7: Cubes of different mix designs

3.4 METHOD OF MIXING AND CASTING OF CONCRETE

The method of mixing adopted is weigh batching using mortar mixture and pan mixture depending on the quantity.

Calculated quantities (all quantities are weighed) of the materials were mixed with required w/c ratio and kept aside.

Dry mix containing cement (+fly ash if used) and aggregates (if any) is prepared and mixed for 2 minutes. Then water and other fluids (if any) are added and mixed for half minute then the foam that is made before hand by mixing water and foaming agent is added and mixed for 1 min. Then it is transferred into the mold and kept on the vibrating table for less than a minute.

This procedure is adopted to cast the specimens. Place the moulds on the vibrating table and pour the wet concrete mix inside the moulds in three layers. Compact the concrete by both through hand compaction using tamping rod and table vibrator. Vibration should not be more, otherwise segregation would happen. After filling the moulds with wet concrete, level the surface. Demold the specimen after 48 hours.

In case if aluminum powder is used the process remains the same in the start, instead of foaming agent aluminum powder is added after the wet mix. Then the mold is filled to half the level with the slurry and kept in the oven at 80 degrees for 6hrs, in this time the aluminum powder reacts with calcium hydroxide to produce hydrogen gas which forms the individual voids in concrete.

4. TESTING OF CONCRETE

The tests conducted are specifically for floating concrete

4.1 DENSITY CALCULATION

After 7 days, the cubes are weighted and all the dimensions are measured, the density is calculated and if the density of the cubes are less than 1000 kg/m3 then further tests can be conducted.

Table 2: Densities for different trials

Trial no.	Density (Kg/m3)
21	850
22	730
24	830
28	880
29	920
30	840
32	970

4.2 FLOATING AND WATER ABSORPTION TEST

3 cubes are placed in water after letting them stay in a room for 7 days, to check if it floats. If they float, then amount of water absorption must be measured. The absorption should only be on the surface, so place the cube in water for 24 hrs. Remove the cube from the water let it surface dry for a few minutes and weight it. The difference in weight is measured and the amount of water absorption is calculated.

Table 3: Water absorption % for trials.

Trial no.	Water absorption %(w/w)
21	1.6
22	1.92
24	1.44
28	1.18
29	0.92
30	1.4
32	0.86

4.3 COMPRESSIVE TEST

The specimen cube test is placed in the CTM, and the load is applied, and the compressive strength is found. [2]

Table 4: Compressive strength for trials.

Trial no.	Compressive strength (N/mm2)	
	(7-day test)	(28-day test)
21	1.81	2.92
22	1.6	2.51
24	2.53	3.90
28	4.34	6.62
29	3.54	5.45*
30	3.63	5.58*
32	6.76	10.40*

**Not tested, it is calculated with reference to 7-day test*

4.4 COMPARISON OF MATERIAL, COST AND STRENGTH

Table 5: Comparison with normal concrete

	M25	M20	M15	FC	Unit cost (Rs./kg)
Density (Kg/m3)	2400	2400	2400	970	
Cement (kg)	470	350	280	450	5.5
Fly ash (kg)	80	60	40	100	1.2
Sand (kg)	550	600	650	0	1
Aggregate (kg)	1080	1220	1300	0	1.2
LWA (kg)	0	0	0	210	4.5
foaming agent (kg)	0	0	0	1.6	80
Water (0.4) (kg)	220	170	130	210	-
7-day strength (MPa)	16.25	13	9.75	6.76	-
28-day strength (MPa)	25	20	15	10.4*	-
Unit cost (Rs./m3)	4,527	4,061	3,798	3,668	-

*Not tested, it is calculated with reference to 7-day test

The comparison shows that floating concrete uses lesser raw materials than conventional concrete and it is economical when produced in bulk.

With lower density it has achieved a compressive strength of 10 MPa, with further research and experimentation higher compressive strength can be achieved.

5. OBSERVATIONS AND DISCUSSIONS

The following observations were made based on the experiments conducted on floating concrete.

1. More the amount of foaming agent, the density decreases but the strength also decreases. The compressive strength decreases with the decrease in density.

2. If there are interconnecting voids the concrete will absorb the water to fill the voids and the specimen will not float, so it is important that the concrete has

individual void which is governed by the proportion of foaming agent.

3. The specimen should be handled with care as it takes time to reach its final strength and while its gaining strength if it is not taken care there will be minor cracks inside which would connect the voids.

4. If aluminum powder is used the w/c ratio should be high and very well mixed. The powder forms individual voids and provides good strength concrete.

5. Aluminum powder is recommended but it requires to be heated to a high temperature before it can be used.

6. Thermocol does not bond with cement in concrete.

7. If curing is done using conventional methods, it will increase the density by filling water inside the voids.

Figure 8: 7 Successful mix design cubes

6. CONCLUSIONS

Based on the study done, the following concluding remarks are made

1. Above mention 7 mix design were experimented floating concrete

2. Perlite can be used as a light weight aggregates.

3. Foaming agent used should be in proper proportion, if less the density would be higher than required and if more is used the concrete obtained will be too brittle.

4. Glass fiber is used to increase the tensile strength of concrete

5. Thermocol as a lightweight aggregate is not found successful.

6. Fly ash is used as a partial replacement of cement to increase the strength.

7. Aluminum powder is used instead of foaming agent.

8. Curing agent should be used or no curing should be done for 14 days.

9. Higher strength can be achieved with further experimentation which could lead to making durable floating islands and also help reduce dead loads in structures.

Figure 9: Scaled model for floating platforms with house.

SCOPE FOR FUTURE STUDIES

1. Floating concrete with higher compressive strength so it can be used as structural elements.

2. Floating concrete with other cementitious materials having lower specific gravity.

3. Floating concrete of larger dimension, and be used as platforms for houses, agricultural farms or solar farms, floating islands, etc.

4. Development of small products made of floating concrete for architectural purpose.

5. Further research into designing of large scaled platforms

6. Development of admixture to help achieve higher strength of floating concrete.

REFERENCES

[1] Thousif Khan, Ibrahim Killedar, Sharu Malik H N, Muhathasheem R F, Jagannatha G M, Dr. Shivakumara B. An Experimental Study on Floating Concrete Using Light Weight Materials. https://www.irjet.net/archives/V5/i5/IRJET-V5I5444.pdf

[2] BUREAU OF INDIAN STANDARDS. (2004). IS 516 - 1959: Method of Tests for Strength of Concrete. IS 516 - 1959: Method of Tests for Strength of Concrete.

[3] Arpit Sharma, ManaliSehrawat, Kamaldeepsingh, MadhurSaraf. Floating concrete by using light weight aggregates. https://www.journalcra.com/sites/default/files/issue-pdf/22553.pdf

[4] Foaming Agent (admixture) https://www.fairmate.com/productscategory/products detail/1/4

[5] Boyd, A. J., &Skalny, J. (2007). Environmental deterioration of concrete. In Environmental Deterioration of Materials. https://doi.org/10.2495/978-1-84564-032-3/05

[6] Mather, B., &Hime, W.G. (2002). Amount of Water Required for Complete Hydration of Portland Cement.