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Experimental study of compressive strength on foam concrete with quarry dust and fly ash

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Abstract -*Concrete is a type of lightweight concrete. It is non-load bearing structural element which has lower strength than conventional concrete. Foam concrete has been successfully used and it has gained popularity due to its lower density than conventional concrete. It is created by uniform distribution of air bubbles throughout the mass of concrete. Recently, most studies on foam concrete concern on the influence of filler type used in manufacturing foam concrete. The density of foamed concrete is a function of the volume of foam added to the slurry and the strength decreases with decreasing density.*

Foamed concrete is a versatile material which consists primarily of a cement based mortar mixed with at least 20-25% of volume air. It is non-load bearing structural element which has lower strength than conventional concrete. In the present investigation, an experimental study is carried on the influence of varying densities of foam in the quarry dust based foam concrete. The range of densities investigated are 800kg/m3, 1000kg/m3, 1200 kg/m3, 1400 kg/m3, 1600 kg/m3, 1800 kg/m3.The density of concrete is varied by using synthetic foam called sodium lauryl sulphate, for 30 liters of water 1 liter of foam is used separately and the same is introduced into the fresh concrete during its mixing by controlling its concentration to its desired density of concrete is achieved.

The focus of this project is to decrease the density of concrete by using optimum content of foam. The results are discussed elaborately with respect to compressive strength. Foamed concrete has unique characteristics that can be exploited in civil engineering works. It requires no compaction, but will flow readily from an outlet to fill restricted and irregular cavities, and it can be pumped over significant distances and heights. Thus it could be thought of as a free-flowing, self-setting fill. This report provides a conspectus of foamed concrete covering its constituents, production, engineering properties and use.

Key Words: Foam concrete, foaming agent, Quarry dust, Flyash, compressive strength.

1. INTRODUCTION

A) Background

Concrete can be categorized into two which are conventional concrete and lightweight concrete. Both concrete shows different properties and usage. Generally, conventional concrete has a density of about 2300 kg/m3, while lightweight concrete has a density between 300 kg/m3 and 1800 kg/m3. The modern types of concrete include cellular or aerated concrete which is light weight and durable, making it easy to be handled. Lightweight concrete is widely used for modern construction as it is mortar less and can be produced with different densities. Lightweight concrete also known as aerated, cellular lightweight concrete, or foam concrete. The first lightweight autoclaved aerated concrete factory was built in 1943 in Emmering, near Munich, Germany. The product is now made in a number of countries in Europe, Asia, South America and the Middle East. This study focuses on usage of quarry dust in Foam concrete.

Foam concrete is classified as lightweight concrete because it contains no large aggregates but only fine aggregate like fine sand, cement, water and foam.

Foam concrete is widely used in construction field and quite popular for some application because of its light weight such as reduction of dead load, faster building rates in construction and lower haulage and handling costs. It also has several advantages because of its porous nature; it provides thermal insulation and considerable saving in materials. The important application of foam concrete includes structural elements, nonstructural partitions and thermal insulating materials. Manufacturers developed foam concretes of different densities to suit the requirements. The density of foam concrete ranges from 300-1800 kg/m3 and these products were used in bridge abutment; void filling, roof insulation, road sub base, wall construction, tunneling etc.

Another material used in the formation of foam concrete is quarry dust as partial material replacement for fine aggregate. Quarry dust is classified as fine material obtained from the crushing process during quarrying activity at the quarry site. In this study, quarry dust will be studied as replacement material to sand as fine aggregate. Quarry dust has been use for different activities in the construction industry such as for road construction and manufacture of building materials such as lightweight aggregates, bricks, tiles and autoclave blocks.

B) Scope of Project

- Casting of concrete specimens by using different densities of foam concrete using quarry dust.
- Review and research of concrete properties using quarry dust based foamed concrete.
- Testing on concrete specimen prepared using foam concrete with different densities.
- Analysis of test results and recommendation for further research area.

2. APPLICATION

Pre-Cast Lightweight Blocks

The most widespread use of foamed concrete in India is for making pre-cast lightweight blocks. These blocks are used to construct non-structural walls in apartments, hotels and offices. Foamed concrete is lightweight which means that the loading on the building is reduced. Therefore the amount of structural steelwork and structural concrete is also reduced resulting in significant cost savings. The thermal insulation properties of foamed concrete mean that there will be greater comfort and reduced air-conditioning and heating costs for tenants.

Cast In-Situ Lightweight Walls

In order to reduce the time and labour needed to make pre-cast blocks, it is possible to cast lightweight foamed concrete walls in-situ. Heights of up to 1m can be cast in a single pour. Normal formwork suitable for concrete can be used. Casting in-situ foamed concrete walls is currently gaining popularity in India.

Void Filling

Foamed concrete does not shrink, is free flowing and fills every gap, even beneath overhangs. It can be placed quickly in large quantities through narrow openings, which means void filling can be tackled with minimal disruption. Both planned and emergency void filling are regularly carried out using foamed concrete. Using traditional methods, the repair would have taken three weeks to be completed, including the dismantling and re- assembly of the road structure, which consisted of pavers bedded in mortar. Using foamed concrete, the whole job was completed and the road re-opened in 48 hours.

Ground Stabilization

The lightweight nature and excellent load spreading characteristics of foamed concrete mean that it is ideal for ground stabilization. During construction of an expressway on a hillside in Japan, traditional granular fill materials were used to construct a large embankment. A landslide caused the embankment to fail. Instead of using traditional fill materials to reconstruct the embankment, a lightweight material needed to be used.

Environmental Benefits

Foamed concrete saves on the use of other materials. It directly saves on material usage since it can be made using fly ash, which is a bi-product of energy generation. Indirectly, since it is lightweight and does not impose large loadings, it reduces the amount steel work and structural concrete required in building construction and civil engineering projects. The most obvious environmental benefit of foamed concrete is its ability to provide thermal insulation

Road Sub-Base

Foamed Concrete can be used to make road structures less heavy. This helps solve the problem where the traditionally heavy road structures cause severe settlement of the road, particularly in areas of soft ground. By constructing the road sub-base from as light weight material, the overall weight of the structure can be greatly reduced. As Foamed Concrete is very versatile, with a wide range of densities, it has proved to be an ideal, cost effective material for solving this problem.

Wall Construction

Foamed Concrete can be used for cast in-situ walls. These can be made either by using traditional shuttering or hollow polystyrene moulds. This provides a quick and cheap method of building, with the added advantage of excellent thermal insulation. A wall made from 1200kg/m^3 density foamed concrete provides the same level of thermal insulation as would a wall made from dense concrete that was 5 times as thick and made from 10 times the quantity of materials as the foamed concrete wall. Tunneling

Ground Works

Foamed Concrete can be used in various types of ground projects, including stabilizing embankments after landslides, highway widening schemes, land reclamation and filling in of harbors. As it does not sink into soft subsoil, redevelopment can begin much sooner after application than can using traditional methods. For similar reasons, it is also ideal for road foundations.

Fire Breaks

The excellent fire resistant properties of Foamed Concrete make it an ideal material for fire breaks in buildings where there are large undivided spaces. It is used to prevent flame penetration through the services void between floor and ceiling in modern construction, and also to protect timber floors in old houses.

Sound Insulation

Foamed Concrete reduces the passage of sound, both from background noise and due to impact. It is, therefore, an ideal material for internal walls and suspended floors in multi-storey buildings, especially ones with communal use.

3. MATERIAL

The materials used in experimental investigation are:

1. 53 grade Ordinary Portland Cement (OPC)
2. Quarry dust
3. Foaming agent
4. Potable water

The properties of the materials are presented in following sections.

3.1 Cement

Portland cement grade 53 is used in this test. It is the basic ingredient of concrete, mortar and plaster. Cement is an amorphous (glassy) powdered siliceous material that responds to the alkali content in cements to react with lime in the high pH environment in concrete to form additional CSH (calcium silicate hydrate) binder within the pore structure of the concrete. Pozzolana is effective as minus 325 mesh powders. Much of the chemistry associated with certain Pozzolana, such as sulfides, carbon, sulfates, and alkalis can be quite deleterious to the long-term durability of concrete. The properties of cement were within limits as per IS 8112:1989. The properties are shown in Table 3.1.

Table 3.1 Physical Properties of 53 Grade Ordinary Portland cement

Sr.NO	Property	Result
1	Fineness	2.7%
2	Specific gravity	3.12
3	Normal consistency	30.5%
4	Setting time(min) a) Initial b) Final	 80 min 305 min

3.2 Quarry dust

Quarry dust is a byproduct of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes; during the process the dust generated is called quarry dust and it is formed as waste. So it becomes as a useless material and also results in air pollution. Therefore, quarry dust should be used in construction works, which will reduce the cost of construction and the construction material would be saved and the natural resources can be used properly. Locally available quarry dust confirming to IS specifications was used as the fine aggregate in the concrete preparation. The properties of Quarry dust were analyzed in accordance with the procedure and were presented in Table3.2

Table 3.2 Properties of Quarry dust

Sr.NO	Property	Result
1	Specific Gravity	2.52
2	Fineness modulus	3.2
3	Grading of sand	Zone 11
4	Density of Quarry Dust	1653kg/m3

3.3. Foaming agent

Foam is a substance formed by trapping pockets of gas in a liquid or solid. A bath sponge and the head on a glass of beer are examples of foams. In most foam, the volume of gas is large, with thin films of liquid or solid separating the regions of gas. Solid foams can be closed-cell or open-cell. In closed-cell foam, the gas forms discrete pockets, each completely surrounded by the solid material. In open-cell foam, gas pockets connect to each other. A bath sponge is an example of open-cell foam: water easily flows through the entire structure, displacing the air. A camping mat is an example of closed-cell foam: gas pockets are sealed from each other so the mat cannot soak up water.

Foams are examples of dispersed media. In general, gas is present, so it divides into gas bubbles of different sizes (i.e., the material is polydisperse) separated by liquid regions that may form films, thinner and thinner when the liquid phase drains out of the system films. When the principal scale is small, i.e., for a very fine foam, this dispersed medium can be considered a type of colloid.
Foam can also refer to something that is analogous to foam, such as quantum foam, polyurethane foam (foam rubber), XPS foam, polystyrene, phenolic, or many other manufactured types of foam. Foaming agent used in the investigation is sodium lauryl sulphate. Foaming used in the study was manufactured by Acuro Organics Ltd, New Delhi Bee Chemicals. Specifications of foaming agent as given by the supplier are given in the following table.
The properties of foaming agent were analyzed in accordance with the procedure laid down and were presented in Table 3.3.

Table 3.3: Properties of Sodium lauryl sulphate

Parameter	Values
Physical State	White Colour
PH	9-10
Specific Gravity	1.05
Stability	Stable under normal condition

3.4. Fly Ash

Fly ash used for this project is class-F fly ash obtained from the electric power plant deep agar Bhusawal Maharashtra
Specific Gravity= 2.62
Bulk Density=2.62 g/cc

4. MIX DESIGN

The process of selecting suitable ingredients of concrete is termed as concrete mix design. The various materials used will be elaborated including the type of foaming agent and mix ration of foaming agent with water to produce stable foam. Since there are no standards for mix proportioning of foam concrete.

Following are the 3 types in which all 9 mixes are studied for this project as:

Type	MIX	CEMENTITIOUS MATERIAL [CEMENT+FLYASH]	SAND+QUARRY DUST
1	M1	100% CEMENT	100% SAND
	M2	100% CEMENT	50% SAND + 50% QUARRY DUST
	M3	100% CEMENT	100% QUARRY DUST
2	M4	70%Cement+30% F.A	100% SAND
	M5	70%Cement+30% F.A	50% SAND + 50% QUARRY DUST
	M6	70%Cement+30% F.A	100% QUARRY DUST
3	M7	40%Cement+60% F.A	100% SAND
	M8	40%Cement+60% F.A	50% SAND + 50% QUARRY DUST
	M9	40%Cement+60% F.A	100% QUARRY DUST

5. RESULTS AND DISCUSSION

The results of the experimental investigation are presented in this chapter. The significance of the results were assessed with the reference to relevant IS codes.

Compressive Strength

The results of compressive strength of foam concrete for different densities of foam are presented in Table 5.1 and Fig.5.1.

Table 5.1 Test Results of Compressive Strength of Concrete

Average compressive Strength (N/mm2)				
TYPE	**MIX**	**7 DAYS**	**14 DAYS**	**28 DAYS**
1	M1	2.06	3.08	3.17
	M2	2.30	3.14	4.30
	M3	3.26	4.59	4.71
2	M4	2.28	3.19	3.26
	M5	3.29	3.66	4.44
	M6	3.81	4.68	5.10
3	M7	2.03	2.66	2.88
	M8	2.24	2.84	3.59
	M9	3.14	4.14	4.30

5.1. For Mix M1, M2 & M3 Compressive Strength where cement used is up to 100% with 1:1 proportion.

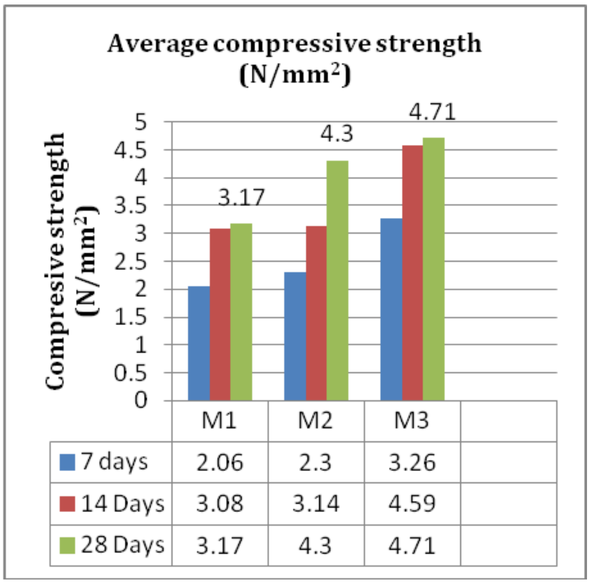

Fig 5.1: Compressive Strength for Mix M1, M2 & M3

5.2. For Mix M4, M5 & M6 Compressive Strength where cement used is up to 70% and Fly ash used up to 30 % with 1:1 proportion (Cementitious to other material).

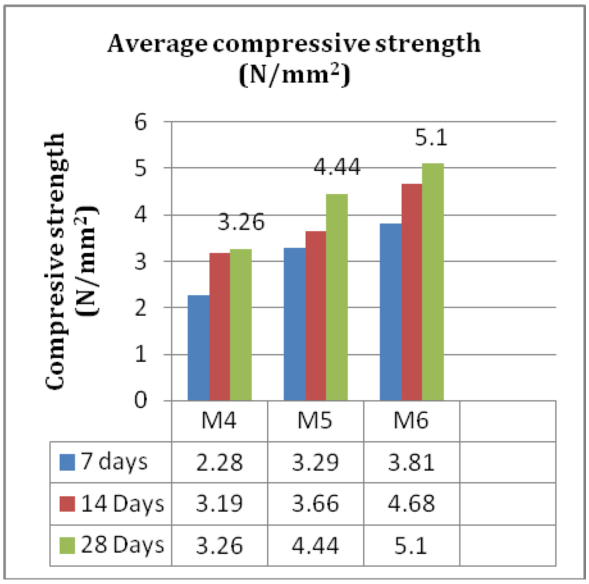

Fig 5.2: Compressive Strength for Mix M4, M5 & M6

5.3. For Mix M7, M8 & M9 Compressive Strength where cement used is up to 40% and Fly ash used up to 60 % with 1:1 proportion (Cementitious to other material).

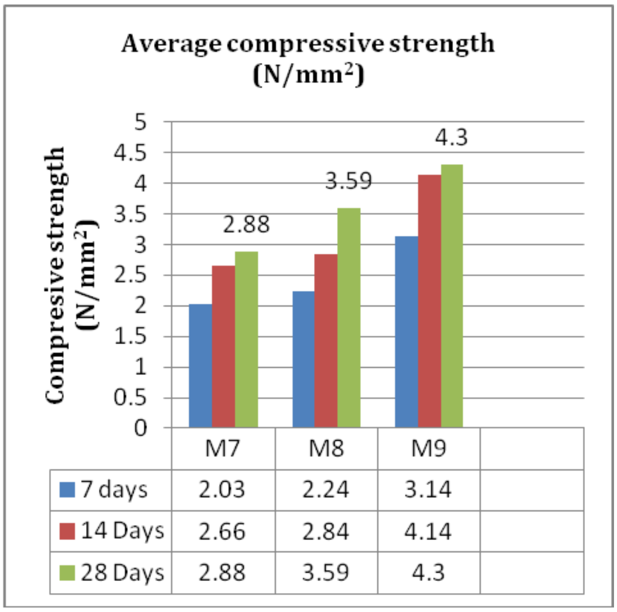

Fig 5.3: Compressive Strength for Mix M7, M8 & M9

5.4. For Trial All Trial Mix M1, M2, M3, M4, M5, M6, M7, M8, M9.Comparitive result for Average Compressive Strength comparison for 7 days, 14 days & 28 days.

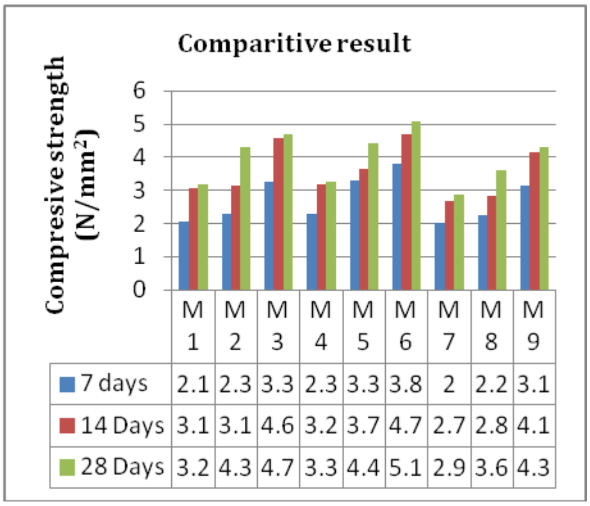

Fig 5.4: Comparative result of all mix

3. CONCLUSIONS

Based on the data obtained from experiment following conclusions can be drawn:

1) In first type M1, M2, M3 shows gradual increase in compressive strength, where as M1 shows lowest & M3 shows highest compressive strength.
2) In second type M4, M5, M6 shows gradual increase in compressive strength, where as M4 shows lowest & M6 shows highest compressive strength
3) In third type M7, M8, M9 does show the same pattern. It means higher percentage of fly ash gives different result when 100% quarry dust is used.

Thus,

Compressive strength of mix M6 having 5.1 N/mm^2 is maximum as compared to other mixes.

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