The Effect on the Properties of Aerated Concrete Developed by Partially Replacing Cement with Flyash and Fine Aggregate with Rubber Powder

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Abstract

Aerated concrete is either a cement or lime mortar, classified as light weight concrete, in which air-voids are entrapped in the mortar matrix with the aid of suitable air entraining agent. Aerated concrete is relatively homogeneous when compared to normal concrete, as it does not contain coarse aggregate phase. It has many advantages when compared with conventional concrete such as reduced dead load, good sound insulation, considerable savings in material as a result of air voids with in aerated concrete. In this study aluminium powder is used as the air entraining agent. The focus of this paper is to study on the effect of properties of aerated concrete developed by partially replacing cement with flyash and fine aggregate with rubber powder. Rubber powder used for this study is made from used tyres of vehicles.
Keywords- Aerated Concrete, Air Entraining Agent, Aluminium Powder, Rubber Powder, Fly Ash

I. INTRODUCTION

Lightweight concrete can be defined as a type of concrete which includes an air entraining agent in that it increases the volume of the mixture while giving additional qualities such as lessened the dead weight. It is lighter than the conventional concrete. The other main specialties of lightweight concrete are its low density and thermal conductivity. Aerated concrete is cellular material consisting of cement and/or lime and sand or other silicious material. This concrete is made by either a physical or a chemical process during which either air or gas is introduced into a slurry, which generally contains no coarse material. Usual methods of aeration are done by mixing in stabilized foam or by whipping air in with the aid of an air entraining agent. This process is usually done by the addition of about 0.2 percent aluminum powder to the mix which reacts with alkaline substances in the binder forming hydrogen bubbles.

Today, waste materials resulting from various physical and chemical processes are the most important challenge in the industrial and developing countries. Extensive investigations are being implemented on wastage recycling in order to minimize the environmental damages. One of the non-recyclable materials enters the environment are automotive used tyres. Investigations showed that used tyres are composed of materials which do not decompose under environmental. So, by using waste rubber from used tyres as a partial replacement of fine aggregate can be a solution to this problem. Also by using fly ash as a supplementary cementing material can make the concrete light weight.

A. Fly Ash

Fly ash is the one of the coal combustion products, composed of the fine particles that are driven out of the boiler with the flue gases. In the past, fly ash was released into the atmosphere, but air pollution control standards now require that it be captured prior to release by fitting pollution control equipment. Nowadays it is used as a pozzolan to produce hydraulic cement or hydraulic plaster and a replacement or partial replacement for Portland cement in concrete production.

B. Rubber Powder

For the last some years, construction industry is taking up the challenges to incorporate sustainability in the production activities by searching for more environmental friendly raw materials. One of the possible solutions for the use of waste tyre rubber is to replace some of the natural aggregates in concrete production. This attempt helps to dispose the waste tyres and prevent environmental pollution.

II. OBJECTIVES OF THE STUDY

- To find out the optimum percentage replacement of cement using fly ash.
- To find out the optimum percentage addition of aluminium powder.
- To develop an aerated concrete by partially replacing cement and fine aggregate with fly ash rubber powder.

III. SCOPE OF THE STUDY

- Study is limited to cement to sand ratio of 1:2.
- In this study cement is partially replaced with fly ash and fine aggregate with rubber powder.
- Aluminium powder used as the only air entraining agent.

IV. METHODOLOGY

1) Finding the optimum percentage replacement of flyash through cement replacement.
2) Finding the optimum percentage of aluminium powder for aerated concrete.
3) Finding the optimum percentage of rubber powder through fine aggregate replacement.
4) Finding the respective densities and compressive strength of aerated concrete.

- Percentage of cement replacement with flyash : 15, 20, 25,30 % by volume of cement
- Percentage addition of aluminium powder: 0.1, 0.25, 0.50, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0 % by weight of cement Percentage of fine aggregate replacement with rubber powder: 5,10, 15 % by weight of fine aggregate.

V. MIX PROPORTIONING

Mix proportion selected for the study is cement to fine aggregate ratio of 1:2

VI. MATERIALS

A. Cement

Ordinary Portland cement is the most common type of cement in general use around the world. Ordinary Portland cement of 53 grades is used for this study. The results of various tests conducted on cement are tabulated in Table 1.

Table 1: Physical Properties of Cement

SI.NO.	Properties	Values	IS Specifications
1	Specific gravity	3.12	3.12 - 3.14 [17]
2	Standard consistency	32%	26% - 33% [17]
3	Initial setting time	76 min	> 30 min [16]
4	Final setting time	360 min	< 600 min [16]
5	Fineness	3.07 %	< 10% [16]
6	Average compressive strength (MPa)	53.2N/mm^2	≥ 53N/mm^2 [16]

B. Fine Aggregate

The fine aggregate used in the study is manufactured sand. Various tests were conducted on fine aggregate and are tabulated in Table 2.

Table 2: Physical Properties of Fine Aggregate

SI.NO.	Properties	Values	IS Specifications
1	Specific gravity	2.75	2.6 – 2.8 [19]
2	Water absorption	4 %	< 12% [19]
3	Fineness modulus	3.98	2 – 3.5 [19]
4	Grading zone	Zone II	[19]

C. Fly Ash

Fly ash selected for this study is low calcium (ASTM Class F) Fly ash. The specific gravity of Fly ash as provided by supplier is 2.2. The major influence on the fly ash chemical composition comes from the type of coal. The physical and chemical characteristics depend on the combustion methods, coal source and particle shape.

D. Rubber Powder
Rubber Powder selected for the study is made from used tyres of vehicles. Manufacturing of rubber powder from used tyres is a three-stage: - (a) shredding, (b) granulation**,** (c) converting the granulated material into the fine powder. The size of the rubber powder used for the study is ranging from 1mm to 2 mm.

E. Aluminium Powder
Aluminium powder is the air entraining agent used for the study. It creates air pores in the concrete and thus makes the concrete aerated. The air-pores in aerated concrete are usually in the range of 0.1 – 1 mm in diameter. The manufactures are NICE CHEMICALS Pvt Ltd, Kerala.

F. Water
Potable water is used for making and curing of concrete.

G. Super Plasticizer
The superplaticizer used for the study is MasterGlenium SKY 8233 supplied by BASF

VII. RESULTS AND DISCUSSIONS

A. Percentage Variation of Fly Ash
The densities and compressive strength of specimens with 0,15, 20, 25, 30 percentages of cement replacement using fly ash are calculated at 7 and 28 days of curing and are tabulated in Table 3 and Table 4.

Table 3: Densities of Specimens with Various Percentages of Fly Ash

Mix ID	Fly Ash (% by vol of cement)	Wet Density (kg/m^3)	Dry Density (kg/m^3)	
			7 days	28 days
CM	0 %	2246.78	2129.47	2119.45
F15	15 %	2044.92	1894.54	1881.75
F20	20 %	2017.91	1872.21	1859.11
F25	25 %	1981.53	1846.72	1835.62
F30	30 %	1973.25	1828.65	1817.34

Table 4: Compressive Strength of Various Percentages of Fly Ash

Mix ID	Fly Ash (% by vol of cement)	Compressive Strength (N/mm^2)	
		7 Days	28 Days
CM	0 %	27.22	40.22
F15	15 %	16.76	23.33
F20	20 %	18.84	29.18
F25	25 %	14.81	18.70
F30	30 %	9.97	12.27

The result from Table 3 indicates that there is a decrease in density of concrete as the percentage of fly ash content increases. This reduction in densities is due to the low specific gravity of fly ash. Table 4 shows that mixes having 20% cement replacement with fly ash had higher strength than other mixes. This higher strength at 20% is due to the pozzolanic activity of fly ash.

B. Percentage Variation of Aluminium Powder
The densities and compressive strength of specimens with different dosages of aluminium powder were calculated at 7 and 28 days of curing and are tabulated in Table 5 and Table 6.

Table 5: Densities of Specimens with Various Percentages of Aluminium Powder

Mix ID	Aluminium Powder (% by wt. of cement)	Wet Density (kg/m^3)	Dry Density (kg/m^3)	
			7 days	28 days
CM	0 %	2246.78	2129.47	2119.45
Al 0.25	0.25 %	1941.18	1797.96	1785.64
Al 0.5	0.5 %	1927.49	1778.34	1765.96
Al 0.75	0.75 %	1901.56	1762.41	1749.36
Al 1.0	1.0 %	1877.29	1744.42	1736.57
Al 1.25	1.25 %	1858.14	1730.75	1722.29
Al 1.5	1.5 %	1837.27	1710.67	1701.33
Al 1.75	1.75 %	1811.35	1684.97	1676.96
Al 2.0	2.0 %	1779.63	1657.96	1650.43

Table 6: Compressive Strength of Various Percentages of Aluminium Powder

Mix ID	Aluminium Powder (% by wt. of cement)	Compressive Strength (N/mm^2)	
		7 Days	28 Days
CM	0 %	27.22	40.22
Al 0.25	0.25 %	17.91	22.12
Al 0.5	0.5 %	14.11	18.1
Al 0.75	0.75 %	11.59	15.78
Al 1.0	1.0 %	10.05	14.07
Al 1.25	1.25 %	8.47	11.92
Al 1.5	1.5 %	7.32	10.54
Al 1.75	1.75 %	6.18	8.83
Al 2.0	2.0 %	5.5	7.97

From Table 5, there is a reduction in density compared to conventional concrete. This reduction in density is due to the presence of tiny air bubbles, which are created on addition of aluminium powder. Table 6 shows that as aluminium powder addition increases strength decreases. Mixes with 0.25% aluminium powder addition had higher strength than other mixes.

C. Replacement of Fine Aggregate with Rubber Powder

Specimens are casted with varying the percentage of rubber powder keeping fly ash at 20% replacement and aluminium powder at 0.25% and 0.5% addition. Densities and compressive strength of specimens are tabulated in Table 7 and Table 8.

Table 7: Densities of the Specimens with Different Percentages of Rubber Powder (Fly Ash 20%)

Mix ID	Aluminium Powder (% by wt. of cement)	Rubber Powder (% by wt. of sand)	Wet Density (kg/m^3)	Dry Density (kg/m^3)	
				7 days	28 days
FA1 R5	0.25%	5 %	1777.05	1650.81	1639.54
FA1R10		10 %	1728.95	1598.77	1591.09
FA1R15		15 %	1707.23	1580.02	1574.63
FA2 R5	0.5%	5 %	1753.45	1620.44	1614.67
FA2R10		10 %	1709.14	1579.89	1575.11
FA2R15		15 %	1697.63	1567.76	1562.61

Table 8: Compressive Strength of Various Percentages of Rubber Powder (Fly Ash 20%)

Mix ID	Aluminium Powder (% by wt. of cement)	Rubber Powder (% by wt. of cement)	Compressive Strength (N/mm^2)	
			7 days	28 days
FA1 R5		5 %	6.85	8.96
FA1R10	0.25%	10 %	4.58	6.23
FA1R15		15 %	3.7	5.03
FA2 R5		5 %	5.503	7.425
FA2R10	0.5%	10 %	3.62	5.04
FA2R15		15 %	3.26	4.48

Table 7 shows that the densities of aerated concrete decreases with the increase of rubber powder content for both 0.25% aluminium content and 0.5% of aluminium content. The addition of rubber powder reduces the weight of the specimens. This reduction in weight is due to the low density of rubber powder. Result tabulated in Table 8 shows that the rubber powder addition decreases the compressive strength of concrete. This reduction in strength is due to the less bonding property of rubber. Mixes with 5% sand replacement with rubber powder had highest strength than other mixes. Mixes with 0.25% aluminium content gave higher strength than mixes with 0.5% aluminium content.

VIII. CONCLUSIONS

From the study it is found out that fly ash and rubber powder can make aerated concrete with lesser density and better strength. Following are the conclusions derived from experimental results:

- As the fly ash content increased in the mix, the density of aerated concrete decreased due to the low specific gravity of fly ash.
- Maximum compressive strength is obtained at 20% flyash.
- When aluminium powder addition increses, the density and compressive strength of aerated concrete decreases.
- Replacement of sand with rubber powder decreases density of aerated concrete.
- Optimum replacement percentage of rubber powder is obtained at 5% by weight of sand.
- Aerated concrete with fly ash and rubber powder gives much less denser concrete with strength in the range of 5 to 10MPa.
- Utilization of fly ash and rubber powder in concrete production can reduce energy costs in processing of natural materials, reduced land disposal and reduced greenhouse gases.

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