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Strength Properties of Light Weight Wall Panels

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Abstract— *Earthquake forces, which affect civil engineering structures and buildings, are proportional to the mass of such structures and buildings. Therefore reducing the mass of the structure is of the utmost importance in reducing seismic risk. This can be achieved by the use of lightweight concrete in construction. Lightweight concrete (LWC) has been successfully used since the ancient roman times. Compared with Normal Weight Concrete (NWC), Lightweight concrete (LWC) can significantly reduce the dead load of structural elements. The panels were made using materials such as cement, sand, fly ash & foaming agents. The Air entraining Admixture (Micro Air-720) will be used for making Lightweight concrete cubes to test their performance and the results will be compared with Normal weight concrete cubes. The primary use of structural lightweight concrete is to reduce the dead load of the structure, which then allows the structural designer to reduce the size of the column footings and other load bearing elements. Structural lightweight concrete mixtures can be designed to achieve similar strengths than the normal weight concrete. The same is true for other mechanical and durability performance requirements. Structural lightweight concrete provides a more efficient strength to weight ratio in structural elements. In most cases, the marginally higher cost of the lightweight concrete is offset by size reduction of structural elements, less reinforcing steel and reduced volume of concrete, resulting in lower overall cost. In buildings, structural lightweight concrete provides a higher fire rated concrete structure.*

Index Terms— Cement*(C), Fly Ash (FA), Air Entraining Admixture (AEA), SuperPlasticiser (S.P)*

1. INTRODUCTION

Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower handling costs. This method has higher consistency due to absence of coarse aggregate and provides excellent heat and sound insulation. There are various methods of producing light weight concrete but they all depend on either the presence of air voids in the aggregate; or the formation of air voids in the concrete by omitting fine aggregate; or the formation of air voids in a cement paste by the addition of sum substances which causes a foam. In some types of light weight concrete, the first two methods may be combined. They are produced from a wide variety of both natural earth substance and fly ash. It mainly consists of cement, air entraining admixtures, and water. The bulk density of this concrete varies from 500 to 1800 kg/m³ whereas the bulk density of ordinary concrete is about 2400 kg/m³.

2. MATERIALS USED AND THEIR PROPERTIES

2.1 Cement

The cement used in this study is 53 Grade, Ordinary Portland cement. The raw materials used for the manufacturing of Portland cement consist mainly of lime, silica, alumina and iron oxide. Four compounds are regarded as the major constituents of cement. They are Tricalcium Silicate (C_3S), Dicalcium Silicate (C2S), Tricalcium Aluminate (C_3A), and Tetra Calcium Aluminate Ferrate (C4AF). The silicates (C_3S and C2S) are the important compounds which are responsible for the strength of hydrated cement paste. The presence of C_3A is undesirable. However, C_3A is beneficial in the manufacture of cement that facilitates the combination of lime and silica. C4AF is also present in small quantities. It reacts with gypsum to form Calcium Sulphoferrite and its presence may accelerate the hydration of silicates. When water is added, the silicates and aluminates of Portland cement form products of hydrates, which in turns produce firm and hard mass. The amount of C_3A in most cement is comparatively small.

2.2 Fly ash

Fly ash is a powdery substance obtained from the dust collectors in the electrical power plants that use coal as fuel. From the cement point of view the mineralogy of fly ash is important. It starts out as impurities in coal- mostly clays, shale, limestone & dolomite. They cannot be burned so they turn up as ash. The fly ash mixtures reached similar to higher long term compressive strengths, due to the pozzolanic properties of the fly ash and the lower w/c ratios. The setting times for the fly ash mixtures were approximately two hours longer. The fly ash mixtures comparable costs, increased compressive strengths, and enhanced durability properties.

TABLE 1
CHEMICAL COMPOSITION OF FLY ASH

Components	% Composition
Silicon Dioxide	49.82
Aluminum Oxide	19.24
Iron Oxide	19.09
Calcium Oxide	4.94
Magnesium Oxide	0.97
Sulfur Trioxide	1.15
Sodium Oxide	0.64
Loss of Ignition	0.56

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2.3 Fine Aggregate

Locally Available river sand is used in the experimental study. Sand is generally considered to have a lower size limit of about 1.18mm or a little less. The process of dividing a sample of aggregate into fraction of particle size is known as sieve analysis and its purposes are to determine the grading or size distribution.

The Construction Chemicals Division of the BASF Group is the provider of Micro Air-720. (Air Entraining Admixture)

The primary purpose of entraining air in concrete is:

1) To improve workability without increasing water cement ratio
2) To make the concrete more weather resistant and in particular against action of frost

Air entraining however causes reduction in the strength of concrete. Air entraining makes concrete more cohesive and fatty, so that the workability is improved without any increase in water cement ratio. The reduction in bleeding and laitance also reduces the danger of scaling in frosty weather. The resistance of concrete to freezing and thawing is considerably increased with the entrainment of air in the form of minute, uniformly distributed and discontinuous air bubbles. The general effects of air entrainment are to increase workability, decrease density, decrease strength, reduce segregation, bleeding and increase durability.

3. Mix Proportions

Mix design is the process of selecting suitable ingredients of concrete an determining their relative quantities with the purpose producing an economical concrete. The mix design should satisfy the properties like maximum strength, water-cement ratio, minimum cement content, minimum workability and air content with specified limits. In order to obtain a satisfactory mix we must check the estimated proportions of the mixes and is necessary to make appropriate adjustment to the proportions until a satisfactory mix has been obtained. In our study various mix ratios (1:2, 1:1, 1:0.5) have been tried and their results are compared.

4. Results and Discussion

4.1 Density of Concrete Vs Percentage of S.P:

Initially the density check for various ratio of cement plus fly ash to super plasticiser (Micro Air-720) are checked and the results are tabulated in the tables 2 to 4 a plot between the percentage of the S.P and the Density of light weight concrete are drawn for each ratio of (C+F):S.P.

TABLE 2

DENSITIES OF CONCRETE FOR RATIO (C+F) 1:2 (S.P)

Mix Proportion	Normal Weight concrete (Kg/m³)	Light weight concrete (Kg/m³) 1% wt of binder	Light weight concrete (Kg/m³) 1.5% wt of binder	Light weight concrete (Kg/m³) 2% wt of binder
1:2 (C+F):S.P	2339	1958	1923	1870
	2263	1974	1935	1893
	2301	1963	1927	1868
	2278	1968	1933	1886
Average	**2295**	**1965**	**1929**	**1879**

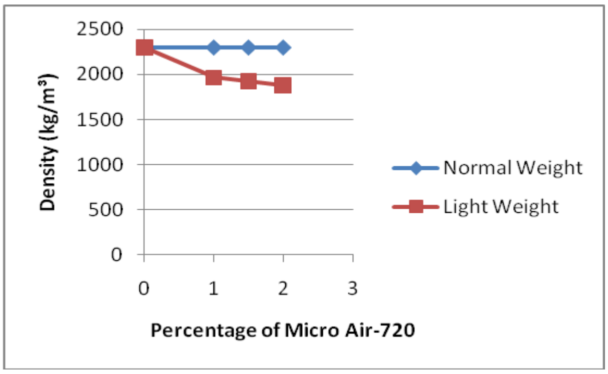

Fig. 1.Percentage of Micro Air-720(S.P) Vs Density of concrete at (Ratio (C+F) 1:2 (S.P))

TABLE 3

DENSITIES OF CONCRETE FOR RATIO (C+F) 1:1 (S.P)

Mix Proportion	Normal Weight concrete (Kg/m³)	Light weight concrete (Kg/m³) 1% wt of binder	Light weight concrete (Kg/m³) 1.5% wt of binder	Light weight concrete (Kg/m³) 2% wt of binder
1:1 (C+F):S.P	1891	1734	1726	1710
	1835	1731	1719	1710
	1860	1730	1723	1708
	1873	1728	1714	1706
Average	**1865**	**1730**	**1720**	**1708**

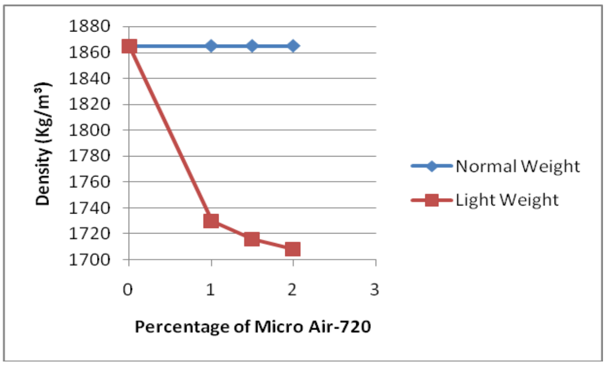

Fig. 2.Percentage of Micro Air-720(S.P) Vs Density of concrete at (Ratio (C+F) 1:1 (S.P))

TABLE 4

DENSITIES OF CONCRETE FOR RATIO (C+F) 1:0.5 (S.P)

Mix Proportion	Normal Weight concrete (Kg/m³)	Light weight concrete (Kg/m³) 1% wt of binder	Light weight concrete (Kg/m³) 1.5% wt of binder	Light weight concrete (Kg/m³) 2% wt of binder
1:0.5 (C+F):S.P	1772	1700	1687	1669
	1821	1681	1667	1631
	1785	1678	1664	1658
	1794	1690	1672	1647
Average	**1793**	**1687**	**1672**	**1648**

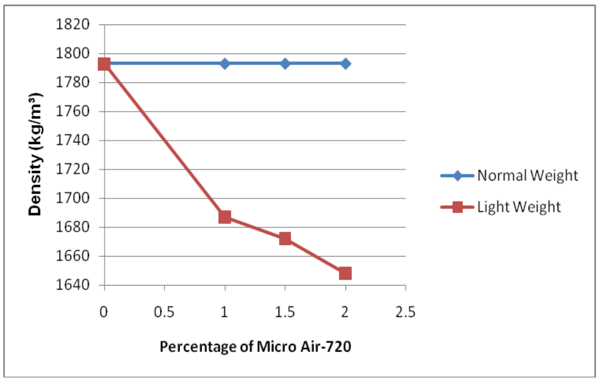

Fig. 3.Percentage of Micro Air-720(S.P) Vs Density of concrete at (Ratio (C+F) 1:0.5 (S.P))

4.2 Compression strength:

TABLE 5

Compressive strength of concrete at 7 days FOR RATIO (C+F) 1:1 (S.P)

Mix Proportion	Estimation of Micro Air-720	Normal Weight concrete (N/mm²)	Light weight concrete (N/mm²)
1:1 (C+F):S	1 % by weight of binder	6.1	5.3
	1.5 % by weight of binder	6.1	5.2
	2 % by weight of binder	6.1	5.0

The compression strength of the wall panels for various ratio of cement plus fly ash to super plasticiser (Micro Air-720) are checked for 7 and 14 days and the results are tabulated in the tables 5 to 7 and plot between the Percentage of Micro Air-720 Vs Compressive strength are drawn.

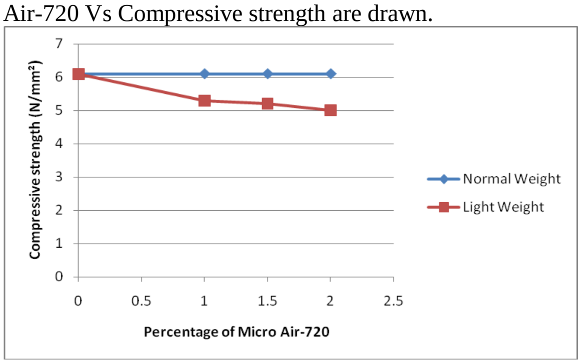

Fig. 4.Percentage of Micro Air-720(S.P) Vs Compressive Strength of concrete at 7 days for (Ratio (C+F) 1:1 (S.P))

TABLE 6

COMPRESSIVE STRENGTH OF CONCRETE AT 7 DAYS for Ratio (C+F) 1:0.5 (S.P)

Mix Proportion	Estimation of Micro Air-720	Normal Weight concrete (N/mm²)	Light weight concrete (N/mm²)
1:0.5 (C+F):S	1 % by weight of binder	9.1	6.5
	1.5 % by weight of binder	9.1	6.2
	2 % by weight of binder	9.1	6.1

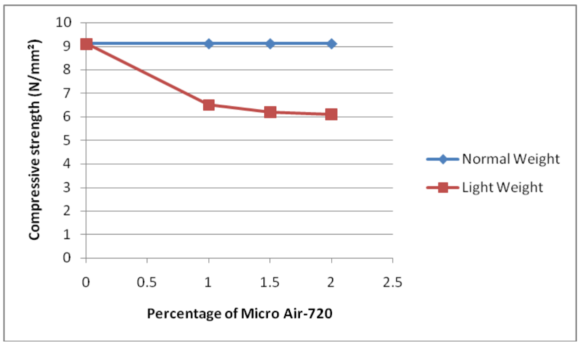

Fig. 5.Percentage of Micro Air-720(S.P) Vs Density of concrete at 7 days for (Ratio (C+F) 1:0.5 (S.P))

TABLE 7

Compressive strength of concrete at 14 days FOR RATIO (C+F) 1:1 (S.P)

Mix Proportion	Estimation of Micro Air-720	Normal Weight concrete (N/mm²)	Light weight concrete (N/mm²)
1:1 (C+F):S	1 % by weight of binder	10.8	5.6
	1.5 % by weight of binder	10.8	5.3
	2 % by weight of binder	10.8	5.2

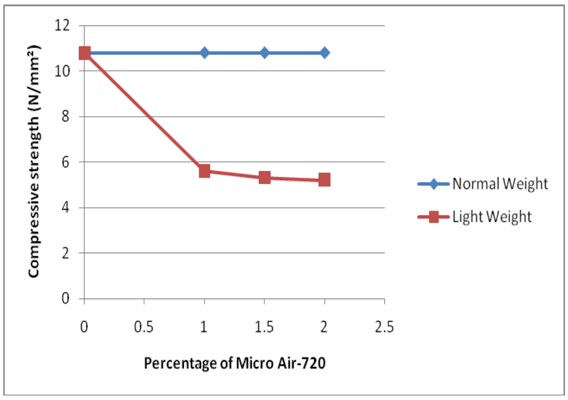

Fig. 6.Percentage of Micro Air-720(S.P) Vs Density of concrete at 14 days for (Ratio (C+F) 1:1 (S.P))

TABLE 8

Compressive strength of concrete at 14 days FOR RATIO (C+F) 1:0.5 (S.P)

Mix Proportion	Estimation of Micro Air-720	Normal Weight concrete (N/mm²)	Light weight concrete (N/mm²)
1:0.5 (C+F):S	1 % by weight of binder	12.7	6.7
	1.5 % by weight of binder	12.7	6.3
	2 % by weight of binder	12.7	6.1

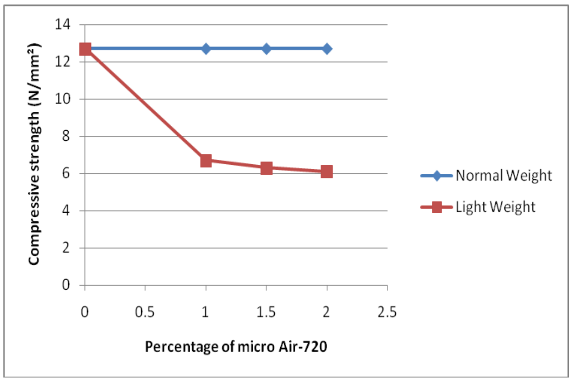

Fig. 7. Percentage of Micro Air-720(S.P) Vs Density of concrete at 14 days for (Ratio (C+F) 1:0.5 (S.P))

Table 5 to 8 shows the results for the compressive strength of concrete with and without adding Air Entraining Admixture and in Fig. 4 to 7 shows plot between the compressive strength of Lightweight concrete at 7 days and 14 days for mix ratio 1:1 and 1:0.5. From Fig.4 the variation of compressive strength of light weight concrete at 7 days for a mix ratio of 1:1 slightly decreases than the Normal weight concrete similarly in Fig 5 the compressive strength of Lightweight concrete at 7 days for mix ratio 1:0.5 is increasing gradually than the mix ratio 1:1.

Similarly from Fig. 6 the compressive strength of Lightweight concrete at 14 days for mix ratio 1:1 slightly decreases than the Normal weight concrete and from Fig.7 the compressive strength of Lightweight concrete at 14 days for mix ratio 1:0.5 is increasing gradually than the mix ratio 1:1

4.3 Flexural strength:

TABLE 9

Flexural strength of wall panels at 14 days

Mix Proportion	Estimation of Micro Air-720	Normal Weight concrete (N/mm^2)	Light weight concrete (N/mm^2)
1:1(C+F):S	2 % by weight of binder	1.73	1.1
1:0.5(C+F):S	2 % by weight of binder	1.92	1.23

From the Table 9 the Flexural strength of wall panels at 14 days for mix proportions 1:0.5 is increased than the mix ratio 1:1for both Normal and Lightweight concrete

5. CONCLUSIONS

Experiments were conducted to find the compressive strengths of concrete with and without

Air Entraining Admixtures. The following conclusions were made based on the experimental investigation:

- Density of concrete decreases with increase of fly ash and Air Entraining Admixture (Micro Air-720)
- Compared with various mix proportions, the ratio 1:0.5 [(C+F):S] gives lesser density
- By using this Air Entraining Admixtures, it is possible to manufacture lightweight concrete with density in the range of 1500-1650 kg/m³
- Compared with Bricks the Lightweight concrete has lesser density
- Compressive strength and flexural strength properties of lightweight concrete wall panel are satisfactory.

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