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EFFECT OF ADDITION OF MICRO SILICA AND FLY ASH ON WORKABILITY AND DURABILITY OF CONCRETE

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ABSTRACT

Due to increase in urbanization and increase in population there has been a tremendous increase in the demand of concrete structure for fulfilling the requirements. This has led to a massive growth in the production of cement. Globally about 5000 million tons of cement is manufactured annually which leads to production of about 2000 million tons of carbon dioxide. This paper gives a thorough investigation into the production of long-lasting concrete using Class F fly ash and Micro Silica. The percentage of replacement cement has been enhanced without sacrificing acceptable qualities by determining an ideal replacement value utilizing two different supplemental cementitious materials. In the first phase of the project, a study was conducted to determine the workability of various concrete mixes containing fly ash and micro silica. The workability of concrete was assessed using the slump cone test. In the final part of work a study on durability of concrete has been done. To check the durability of concrete accelerated carbonation test and water permeability test have been performed.

Keywords: Concrete, Durability, Workability, Carbonation, Permeability, Fly Ash, Micro Silica.

I. INTRODUCTION

Concrete is one of the major building materials required for construction of structures concrete buildings, concrete bridges, rigid pavements etc. Since concrete is stronger in compression, therefore the basic purpose of using concrete is to provide required compressive strength to the structural elements that are constructed by using concrete alone or concrete along with other materials. But over the years there has been a rapid change in the field of construction technology that has subsequently led to the change in all kinds of things related to it. There was a requirement of concrete that has improved compressive as well as tensile strength. There was a requirement of concrete that has properties like self-compaction, self-healing, improved workability, improved early age strength, reduced carbon footprint etc.

A detailed work has been done on development of sustainable concrete. Research on numerous engineering properties of said concrete has been presented in various reputed journal. Following a thorough review of these studies, it is possible to infer that the use of materials such as fly ash, silica fumes, GGBS, or other types of pozzolanic improve the durability of concrete in general. Although much research has been done on the subject of the durability of sustainable concrete, the majority of these studies have focused on the mechanical qualities and durability of concrete. However, it was shown that while the addition of fly ash increases the workability of concrete, the addition of micro silica or nano silica diminishes it. The workability of concrete is a key aspect in determining its quality, as poor workability restricts the use of concrete for a wide range of applications. Also most of the work done on sustainable concrete has been limited to either use of a single type of pozzolanic material or keeping the percentage of one type of pozzolanic material constant and varying the percentage of second type of pozzolanic material used to partially replace the cement. So this study aims at replacing cement partially by three percentages of micro silica along with three different percentages of fly ash. A total of nine different combinations have been used to partially replace the cement. The goal of utilising fly ash in concrete is to improve its durability and workability, whereas the goal of using micro silica in concrete is to raise the rate of hydration and density.

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II. OBJECTIVES

The key objectives of present work are as under:-

1. To investigate the effect of addition of various combinations micro silica and fly ash on workability concrete.
2. To investigate the effect of different combinations of fly ash and micro silica on permeability of concrete.
3. To investigate the effect of different combinations of fly ash and micro silica on durability of concrete.

III. METHODOLOGY

The current work comprises an experimental analysis of blended concrete with nine distinct combinations of micro silica and fly ash replacing cement. The percentages of fly ash used are 20%, 30% and 40%.While the percentages of micro silica used are 7%, 14% and 21%. A total of nine different combinations have been used. All combinations used have been tabulated below along with their code:

Table 1: Details of different concrete mix used in this research work

S. No	Code	Fly Ash %	Micro Silica %	Cement %
1	Reference Mix	0	0	100
2	F20 S7	20	7	73
3	F20 S14	20	14	66
4	F20 S21	20	21	59
5	F30 S7	30	7	63
6	F30 S14	30	14	56
7	F30 S21	30	21	49
8	F40 S7	40	7	53
9	F40 S14	40	14	46
10	F40 S21	40	21	39

IV. TESTING OF CONCRETE

Various experiments on fresh and hardened concrete were carried out as part of this study. All the necessary codal provisions as per relevant IS code have been followed during respective testing of concrete. The list of tests performed in this study have been listed below:

i. Workability Test
ii. Compressive Strength Test
iii. Permeability Test
iv. Carbonation Test

V. RESULTS AND DISCUSSION

The findings of the concrete testing have been thoroughly discussed in this chapter. The grade of concrete selected for the study was M30. For investigation as per requirement of the research cement in the concrete was partially replaced by 20%, 30%, 40% fly ash and 7%, 14%, 21% micro silica in combination with each other. On fresh concrete, a slump cone test was done, followed by several durability tests on hardened concrete. Carbonation and water permeability experiments were performed as part of the durability testing. Concrete was also subjected to a compressive strength test in order to determine its mechanical qualities. A tilting type mixer was used to properly mix the concrete, which was followed by the filling of the moulds. For performing permeability and compressive strength tests (150x150x150) mm moulds were used and for performing carbonation tests (100x100x100) mm moulds were used.

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Table 2: Slump test results

S. No.	Combination	Slump Value (mm)
1	Reference mix	60
2	F20 S7	75
3	F20 S14	65
4	F20 S21	60
5	F30 S7	80
6	F30 S14	75
7	F30 S21	70
8	F40 S7	90
9	F40 S14	85

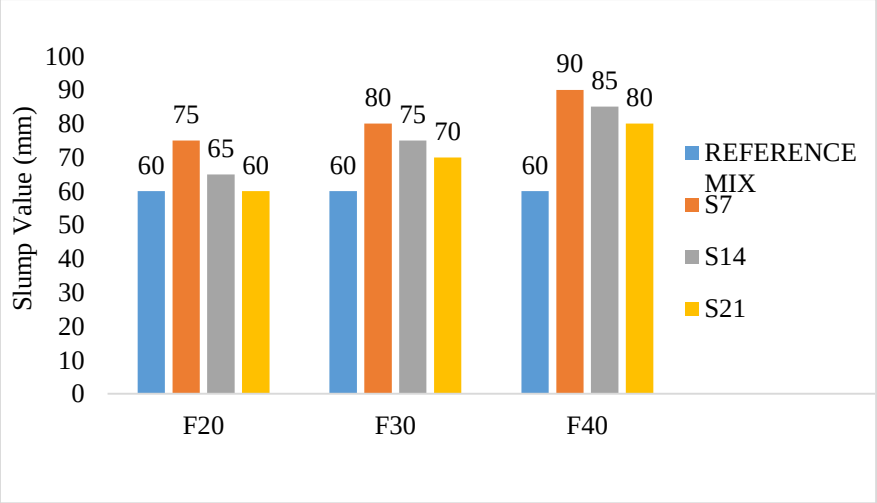

Figure 1: Slump Test Results

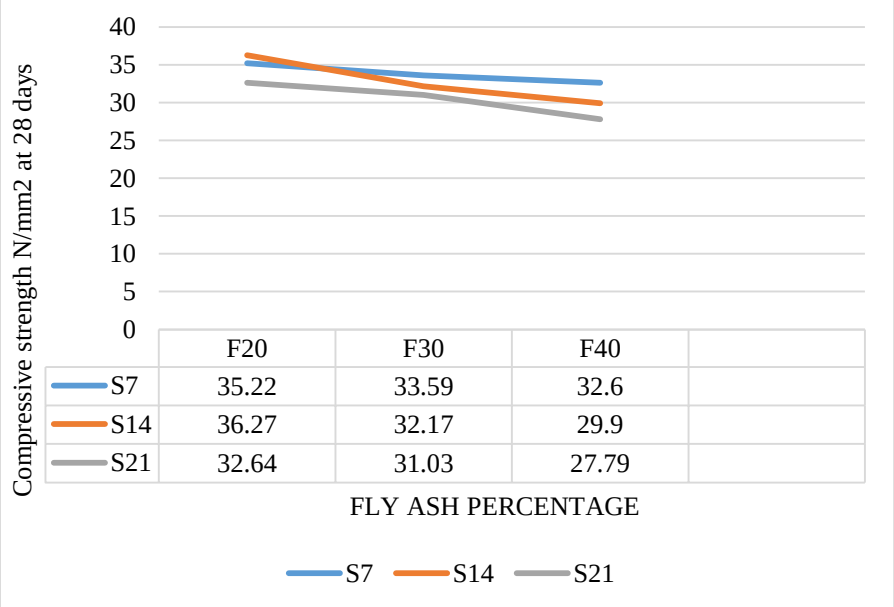

Figure 2: Compressive Strength Test Results

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Figure 3: Carbonated Concrete

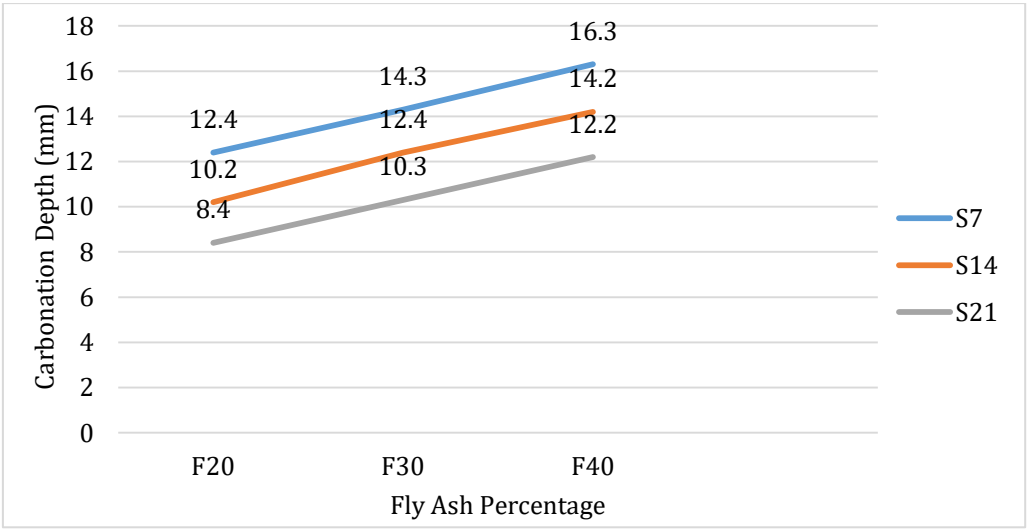

Figure 4: Carbonation Test Results

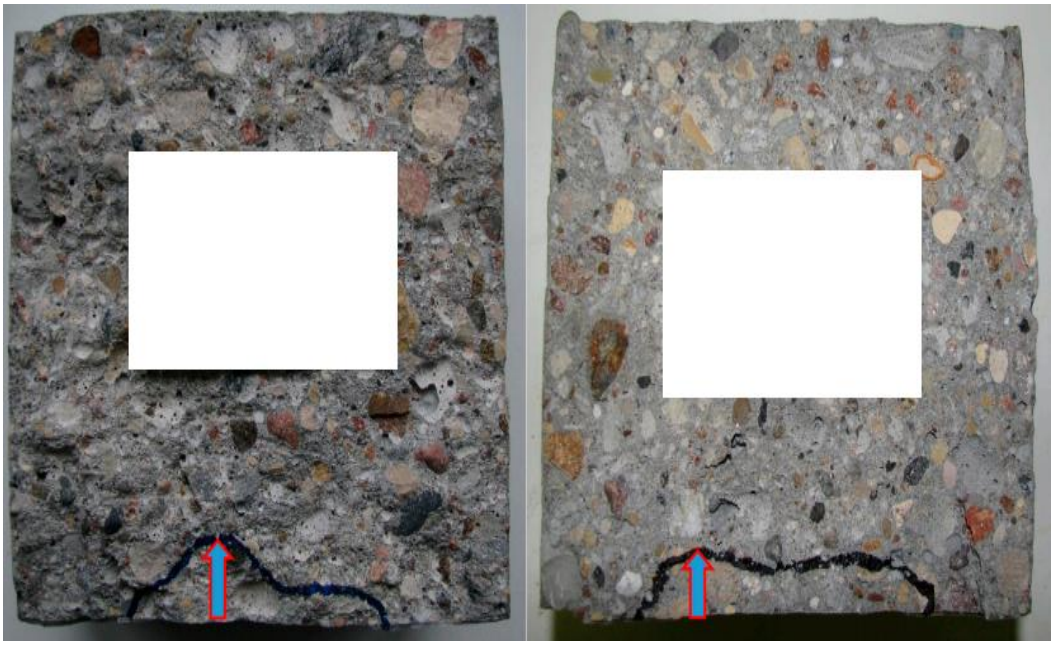

Figure 5: Water Permeability of Concrete

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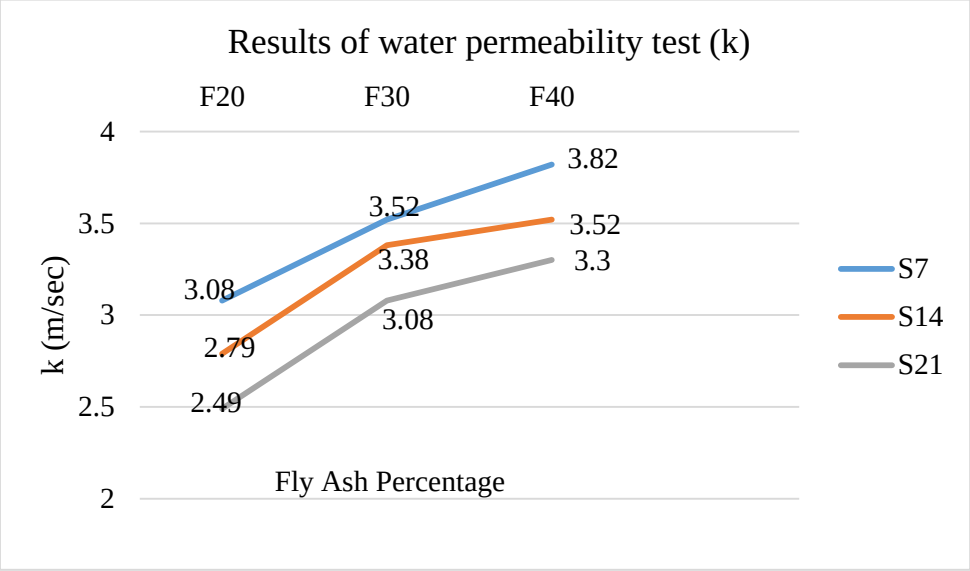

Figure 6: Water Permeability Test of Concrete

VI. CONCLUSION

- The workability results show that as the amount of fly ash in the concrete increases, so does its workability. This is mainly because of the spherical geometry and smooth texture of fly ash due to which there is addition of lubricative fluid and reduction in water demand for maintaining same workability. But on the other hand workability was found to get reduced on increasing the content of micro silica. This is mainly because of the fact that particles of micro silica are finer than that of cement particles and fly ash which increase the requirement of water content due to increase in surface area to be lubricated. Also micro silica accelerates the process of hydration which ultimately decreases the workability of mix.
- When cement was substantially replaced with fly ash, the 28-day strength of the concrete was significantly reduced. Because fly ash slows the rate of strength growth, the 28th day strength of fly ash concrete is typically lower than that of concrete that does not include fly ash. However, when cement was replaced with micro silica in fly ash concrete, there was an increase in strength, and it was discovered that adding micro silica to concrete improves its compressive strength. The F20S14 mix, which contains 20% fly ash and 14% micro silica, was judged to be the best value for substitute or replacement.
- The addition of fly ash has a detrimental influence on the carbonation resistance of concrete, according to the results of the carbonation test. The addition of fly ash to concrete increased the carbonation depth. After 28 days of exposure, the carbonation depth measured in the reference mix was 10.3 mm, whereas the lowest carbonation depth was obtained in a mix comprising 20% fly ash and 21% micro silica, known as F20S21 in this study The main explanation for the negative effect of fly ash on concrete carbonation resistance is that adding fly ash reduces the alkaline reserves of the concrete due to the consumption of $Ca(OH)_2$, which speeds up the carbonation process. Micro silica, on the other hand, diminishes concrete's alkaline reserves while simultaneously increasing its density, which reduces permeability and so limits carbon dioxide penetration into the concrete.
- The results of a water permeability test performed on concrete samples to investigate the permeability of concrete confirmed the results of the accelerated carbonation test. The permeability of concrete rose with the addition of fly ash, but decreased with the addition of micro silica. Permeability depth of the reference mix was measured as 21 mm and lowest value of permeability was measured in concrete mix containing 20% fly ash and 21% micro silica designated as F20S21 in this research work. Water permeability was also measured by calculating the coefficient of permeability for different concrete mixes. The results obtained showed the mix F20S21 has least value of coefficient of permeability and mix F40S7 has the maximum value of coefficient of permeability. These results were validating the results of the water penetration test.

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