International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 9 (2019) pp. 2203-2206

A Study on Investigation of Micro Silica as Partial Replacement of Cement in Concrete

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Abstract

The concrete is the most extensively used construction material in the world. Now a days the cost of the building materials is increasing and availability of the material is decreasing. Due to the production of cement CO_2emission is also increasing. To overcome all these, the cement is partially replaced by the supplementary materials like Micro Silica, Metakaolin, Fly-ash, Ground Granulated Blast Furnace Slag (GGBS) etc. In this work, micro silica is used for partial replacement of cement. Micro Silica is a by-product obtained from Silicon and Ferro Silicon alloy industries. Split tensile strength tests on concrete are conducted with partial replacement of cement with various percentages of 0%, 10%, 12.5%, 17.5% , 20%, and 22.5% of micro silica. Thus concrete cylindrical specimens were prepared, cured, tested and compared in terms of split tensile strength. From the obtained results it is concluded that the maximum split tensile strength is attained at 12.5% replacement of cement with micro silica.

Keywords: Split tensile strength, Concrete, Microsilica, Pozzolona, Cement

1. INTRODUCTION

Concrete structures are exposed to harsh environments and are expected to withstand longer periods of time. For this, concretewhich have better strength are being experimented with different materials based upon their availability and its behavior in concrete. Micro Silica is by-product of ferro silicon alloys industries and high quality quartz producing industries which uses electrical furnaces. The replacement of Portland cement upto some extent with micro silica leads to significant reduction of carbon dioxide gas emission. Micro silica concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack.

DebabrataPradhan et al.,(2013), investigated the effect of micro silica on the properties of hardened concrete. They investigated with M40 grade concrete with partial replacement of cement by micro silica with different proportions of 0%, 5%, 10%, 15% and 20% conducting compressive strength test and split tensile strength tests. They concluded that the optimum percentage of replacement with micro silica is at 20% for compressive strength and same for spilt tensile strength.**Lakhbir Singh et al.,(2016)**, investigated the effect of micro silica on the properties of hardened concrete. They investigated with M30 grade concrete with partial replacement of cement by micro silica with different proportions of 0%, 5%, 10% and 15% conducting compressive strength test and split tensile strength tests. They concluded that the optimum percentage of replacement with micro silica is at 10% for compressive strength and same for spilt tensile strength.**Hanumesh et al., (2015),** investigated the effect of Micro silica on strength and durability parameters of Concrete. They used the concrete mix design of M20 grade with different proportions of 0%, 5%, 10% 15% and 20% conducting compressive strength and Split tensile tests at 7 days and 28 days. They concluded that optimum strength obtained at 10% of micro silica**.Lakhbir Singh et al.,(2016**), investigated the effect of micro silica on the properties of hardened concrete. They investigated with M30 grade concrete with partial replacement of cement by micro silica with different proportions of 0%, 5%, 10% and 15% conducting compressive strength test and split tensile strength tests. They concluded that the optimum percentage of replacement with micro silica is at 10% for compressive strength and same for spilt tensile strength.**JathinkumarB.Patel (2016),** investigated the strength and durable properties of concrete having Micro silica as partial replacement to cement . They used the concrete mix design using IS 10262-2009 of M25 mix with different proportions with 3%, 5%, 7%, 9%, 11%, 13% and 15%. They concluded that optimum results are obtained at replacement of 11%.

1.1 Micro silica

Micro Silica is a pozzolonic material which is environmentally stable and proven itself as good touse all over the world since 1900. It is a industrial byproduct of high purity quartz industries and ferro-alloy industries. Generally, size of micro silica varies from 10nm to 1000nm. First test of silica fume in concrete is done in 1952. The use of micro silica in concrete become prominent from 1970. The use of micro silica in concrete reduces bleeding, segregationand increases workability of the concrete.

Figure 1. Micro silica

2. MATERIAL TESTS CONDUCTED

2.1 Cement

53 grade Ordinary portland cement is used for this work. Following tests are conducted on cement as per IS 12269:1987 and results are as follows

1. Standard consistency - 34%
2. Initial setting time - 60 minutes
3. Specific gravity - 3.12

2.2 Fine aggregate

Locally available river sand of Zone-II is used.Following tests are conducted on Fine aggregate as per IS 383:1970 and observed results are asfollows

1. Sieve analysis - Well graded sand
2. Specific gravity - 2.54
3. Bulk density - 1574kg/m^3

2.3 Coarse aggregate

Stones from local quarry is used.Following tests are conducted on Coarse aggregate as per IS 383:1970 and observed results are as follows

1. Specific gravity - 2.73
2. Bulk density - 1620kg/m^3

2.4 Concrete

Workability tests are conducted on concrete and observed results are as follows

1. Slump cone test - 40mm
2. Vee bee test - 7 sec
3. Compaction factor test - 0.78

2.5Micro silica

Locally availed Micro silica is used.Following tests are conducted on it and observed results are as follows

1. Specific gravity - 2.29

3. Mix Design (IS 10262:2009)

Grade of concrete: M30

Type of cement : OPC 53 grade

Maximum size of aggregate : 20mm

Maximum cement content : 450kg/m^3

Adopted water-cement ratio : 0.40

Target strength for mix proportion (f_{ck1}) : 38.25 N/mm^2

For 1m^3 of concrete

Cement = 350 kg/m^3

Water = 140 lit

Fine aggregate = 885 kg/m^3

Coarse aggregate = 1141 kg/m^3

Ratio = 350: 885 : 1141

Mix proportion = **1 :2.53 : 3.26**

4. METHODOLOGY

Split Tensile test

Micro silica is replaced with the cement in the ratios of 0% (control concrete), 10%, 12.5,15%,17.5%,20%,22.5%. Three test cylinders specimens of 150mm dia and 300mm in length were prepared of every case for 7 and 28 days curing. Split tensile strength is determined for cylinders by using split tensile testing machine of 1000kN as per IS 5816:1999.

Figure 2. Split Tensile Strength Machine

5. RESULTS AND DISCUSSION

5.1 For 7 days curing

Split tensile strength of the concrete cylinders after 7 days curing for various proportions of Micro silica are follows

Table 1. Split Tensile Strength after 7 days curing

% replacement of cement with Microsilica	Split tensile load taken by the cylinder after 7 days curing (in KN)			Avg. load (in KN)	Split tensile strength (in N/mm^2)
	Specimen 1	Specimen 2	Specimen 3		
0%	115	120	130	121.66	1.72
10%	140	135	125	133.33	1.88
12.5%	150	145	160	151.66	2.14
15%	130	140	145	138.33	1.95
17.5%	125	115	140	126.66	1.79
20%	120	125	105	116.66	1.65
22.5%	100	105	115	106.66	1.50

Graph is drawn by taking percentages of cementreplacement withMicrosilica on X- axisand split tensile strength of the cylinders after 7 days curing on Y- axis.

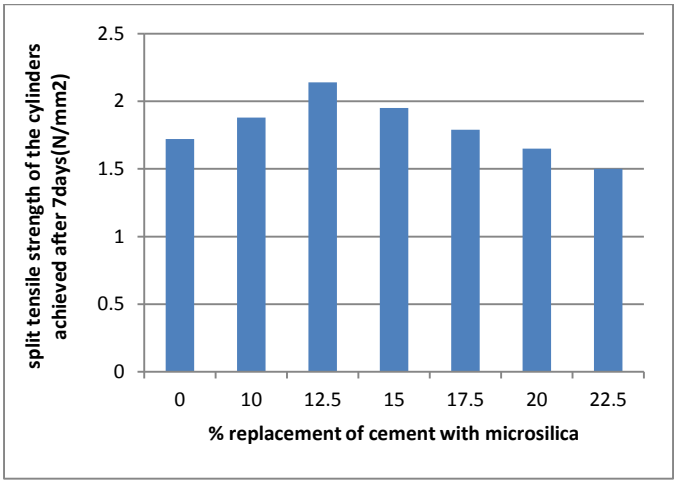

Figure 3. Split Tensile Strength after 7 days curing

From above graph, it can be observed that maximum split tensile strength of the cylinder after 7 days curing is achieved at 12.5% replacement of micro silica and the value is 2.14 N/mm^2.

5.1.2. After 28 days curing

Split tensile strength of the concrete cylinders after 7 days curing for various proportions of Micro silica are follows

Table 2. Split Tensile Strength after 28 days curing

% replacement of fine aggregate with Micro silica	Split tensile load taken by the cylinder after 28 days curing (in KN)			Avg. load (in KN)	Split tensile strength (in N/mm^2)
	Specimen 1	Specimen 2	Specimen 3		
0%	155	160	140	151.66	2.14
10%	200	205	210	205	2.90
12.5%	240	225	250	238.33	3.37
15%	210	215	230	218.33	3.08
17.5%	190	205	195	196.66	2.78
20%	170	185	180	178.33	2.52
22.5%	160	165	165	163.33	2.31

Graph is drawn by taking percentages of cementreplacement withMicrosilica on X- axis and split tensile strength of the cylinders after 28 days curing on Y- axis.

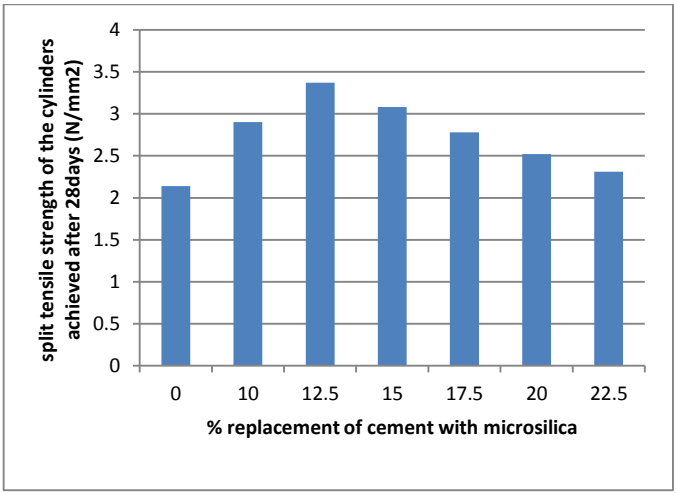

Figure 4. Split Tensile Strength after 7 days curing

From above graph, it can be observed that maximum split tensile strength of the cylinder after 28 days curing is achieved at 12.5% replacement of micro silica and the value is 3.37 N/mm^2.

6. CONCLUSIONS

1. The maximum split tensile strength is obtained at 12.5% replacement of cement with Micro silica and further increase in percentage of micro silica leads to decrease in split tensile strength.
2. Micro silica addition to concrete resulted in decrease of voids in concrete and reduced capillary
3. We can reduce Co_2 emissions in environment by partially replacing microsilica with cement.

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