

Insertion of Nano silica and Metakaolin as Additive in Reactive Powder Concrete

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Abstract - The work is carried out to study the workability and strength performance of reactive powder concrete in nano and micro scale. The application of Micro or Nano technology in concrete has added a new element to increase its properties. Nano materials, by benefit of their very small particle size can affect the properties of concrete by varying the microstructure. By partial replacement of Nano silica and Metakaolin improves the properties of microstructure and also reduces the pores in cement mortar. The main objective of this study was to investigate the fresh property was conducted by a workability test and strength properties was conducted by compressive strength in 3, 7 and 28 days of Reactive powder Concrete by combining 4%,5%,6% of Nano silica and 10% by the cement weight. The mix, grade M75 with a water-cement ratio of 0.26 is adopted.

Key Words: Reactive powder concrete, Nano silica, Metakaolin, High strength, High Performance.

Abbreviations: RPC – Reactive Powder Concrete, NS-Nano Silica, MK – Metakaolin, OPC-Ordinary Portland cement, NGS - New Generation Superplasticizers.

1. INTRODUCTION

Reactive powder concrete is also called as High performance concrete which is produced by combining supplementary cementitious materials, reactive powders and by using high amount water reducers, this combination provides excellent performance in some properties of concrete. In recent scenario a new term, "Reactive Powder Concrete" is used for concrete mixture which has greater strength, greater density, high dimensional stability, low permeability, resistance to chemical attack, and better Resistance to existing environmental agents etc. The concrete made based on the necessity of satisfying the criteria proposed to overcome the limitations of a conventional concrete can be said as RPC. To increase the properties of transition zone, use of silica fume becomes an essential constituent for attaining more strength (More than 50 Mpa). The good quality Metakaolin may be used for other nominal benefits. Both materials which acts as nano nucleating agent at very early ages. It is difficult to maintain normal workability with less w/ c ratio, to overcome that crux the Polycarboxylic ether based superplasticizer is added as per the specifications given in IS Code.

2. MATERIALS

2.1 Cement: The Ordinary Portland cement (OPC) is used in this study (Type-ASTM), Different tests are conducted for the sample of cement to check the quality such as specific weight, fineness, soundness of cement, initial and final setting time.

2.2 Nano Silica:

Nano silica is obtained from Supreme Chemicals, Gujarat. The avg. diameter of particle is 10µm. The chemical composition is given in Table No – I.

Table I – Chemical Composition

Content	Weight %
SiO ₂	99.6
Na ₂ O	0.28
Al ₂ O ₃	0.07
Sulphate	0.04
Fe	0.01

2.3 Metakaoline:

Metakaolin had less than <16 µm of about 98% particles with a mean particle size of about 2 µm Table II gives the physical properties and The typical chemical composition is given in Table II.

Table II - Physical Properties:

Properties	Range
Bulk Density g/m ³	0.4
Specific Gravity	2.56
Fineness of Metakaolin	750 – 850 m ² /kg

Table III – Chemical Composition

Content	Weight %
SiO ₂ - Silica	51.52
TiO ₂ -	51.52
Al ₂ O ₃	3 40.18
Fe ₂ O ₃	203 1.23
MgO	0.12
CaO	2.0
Na ₂ O	0.08
K ₂ O	0.53

3. Mix Proportion

Table IV - Mix Proportion Details

Specimen Batch	OPC	MK	NS
A	100	0	0
B	B ₁	86	10
	B ₂	85	10
	B ₃	84	10

Different mix proportions are made by keeping MK constant with 20% and varying in the NS by 4%, 5%, and 6% in the place of OPC

4. Tests:

Workability Test:

The workability test is carried out, and compared between OPC with Different proportions to find out the Subsidence known as slump. This test is conducted by referring IS-1199-1959. This test is carried out to know the subsidence of reactive powder concrete because which contains less water to cement ratio. To maintain the workability new generation superplasticizers are used.

Compressive strength:

The test is conducted by preparing the moulds of size 150x150x150 mm, as per IS: 516-1959. The research specimens are labelled and removed from the moulds and, unless appropriate for testing within 24 hours, they are immediately immersed in clean fresh water and kept there until they have been removed just before testing. The research specimen is placed in CTM (2000 KN capacity) between steel plates. The load is applied at the rate of 140 Kg/Cm² /min and the load failure is noted down in KN.

5. Results and Discussion

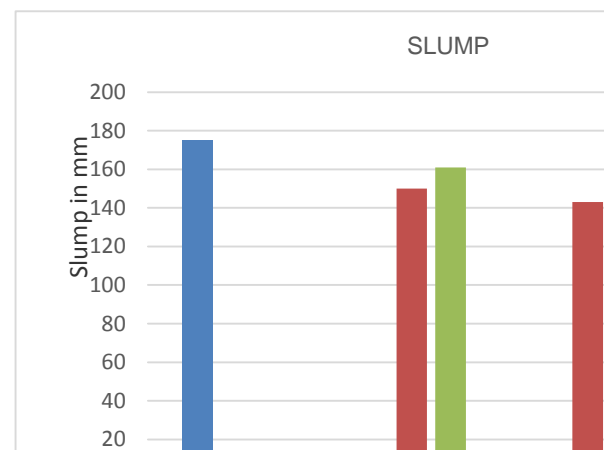
Workability Test:

The outcome on workability of reactive powder concrete is tabulated in Table – VI and shown in Fig. 4.1. Reduction in the workability by addition of nano silica and metakaolin as compare to the OPC. The higher the amount of nano silica and metakaolin lower the slump the value. But some amount of increase have been seen by adding the NGS - New Generation Superplasticizers.

Table V – Slump Result

Specimen Batch	Subsidence or Slump in mm	
	Without NGS	With NGS
A	175 mm	
B	B ₁	150 mm
	B ₂	143 mm
	B ₃	134 mm

*NGS - New Generation Superplasticizers.

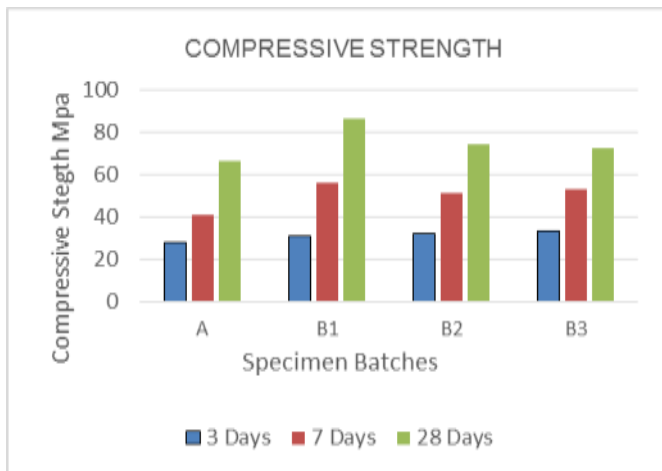


Compressive strength:

Table VI – Compressive strength Result

Specimen Batch	Compressive Strength Mpa		
	3 Days 40	7 Days 65	28 Days 99
A	28	41	66
B ₁	31	56	86
B ₂	32	51	74
B ₃	33	53	72

The research specimens were tested strength property by selecting compressive strength test as a strength indicator. All specimens were (B₁, B₂, and B₃ with New Generation Superplasticizer Type) with compared with OPC. The strength property of all specimens were tested on 3, 7, and 28 days. The addition of Nano silica and Metakaolin shows slow reaction in the strength development. As per the results B₁, B₂ and B₃ shows greater strength over OPC. But B₁ is attained more strength as compare to the same batch of B₂ and B₃. The B₁ mix at early stage (3 Days) Shows less value as compare to B₂ and B₃, but later the strength enhanced on 7 and 28 days.



VI. CONCLUSIONS

The conclusion of this study is specified below as follows:

- The reduction in workability have been seen due to the addition of the nano silica and metakaolin as compare to OPC. Due to the less water to cement ratio and increase in the surface area of the RPC.
- The nano silica and metakaolin performed as a filler which makes the concrete densified and improves the pore structure of concrete and this concrete is act as reactive powder concrete at micro level.
- The addition of nano silica and metakaolin showed a greater result of the compressive strength at later stage after 3 and 7 days as compare to OPC.
- The compressive strength development is taken in place with 4% and 10% addition of nano silica and metakaolin.
- The presence of nano silica and metakaolin improvement is taken place in nucleating agent at very early age which resulted the greater development of compressive strength at later stage.

V. FUTURE SCOPE

- To achieve concrete construction economy and to use Metakaolin effectively in an environmentally friendly way.
- To introduce this reactive powder concrete in to Ultra high performance concrete.
- To compensate the deficiency occurring in initial days by utilizing the Nano silica and Metakaolin.
- Manually it is difficult to attain greater strength and high performance of concrete, which requires a proper mixing proportions. So its need some global optimization method to develop the desired results with greater accuracy and shorter time.

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