

Practical R & D Innovations in Concrete Technology

Part-2

By

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1.0 Ultrafine SCMs

1.1 Preamble:

Various ultrafine SCMs are:

- a) Ultrafine Fly Ash (UFFA);
- b) Ultrafine Slag (UFS) – patented Name Alccofine-1203;
- c) Micro silica (MS) or Silica Fume (SF);
- d) Metakaoline (MK);
- e) Rice Husk Ash (RHA).

Let us discuss Micro Silica and Alccofine 1203 in little more details.

1.2 Micro Silica (M.S.):

- 1985: First time used in high strength concrete in USA.
- 2002: First time used in India in high strength high performance concrete M75, in J.J. Flyover construction, Mumbai. Since then used in all High Strength High Performance Concrete of M60 and higher grade all over India.
- 2009: Manufacturing of Alccofine 1203(UFS) started in Goa.

2.0 Alccofine for Quality Improvement and Cost Reduction in Concrete:

It is a **PATH BREAKING** Indian innovation done in Goa.

- ❖ What is Alccofine-1203?
- ❖ It is ultrafine GGBS, manufactured in India by patented process (patented in Goa, India)
- ❖ Its fineness is around 4 times that of cement.
- ❖ Particle size gradation is **highly controlled**. Records of 9 years indicate variation in any particle size is less than 0.2 micron with respect to PSD curve.
- ❖ Presently, there is also relevant BIS code viz. IS 16715 (2018).

2.1 Is there any product close to Alccofine-1203

- ❖ Yes, that product is Micro-silica. (MS)
- ❖ It is around 65 times finer than cement.
- ❖ But generally available in condensed form, condensed closely to cement particle size.
- ❖ Main advantages of MS are
 - ❖ Early strength gain
 - ❖ Early high impermeability but it is imported product either from Bhutan, China and Norway.
 - ❖ The relevant IS Code is IS-15388 (2003).

2.2 Alccofine-1203 v/s Micro-silica

- ❖ **Beneficial Points**
 - ❖ Early strength and early high impermeability. Both are equal, rather Alccofine-1203 is little superior as shown in graphs. (Studies by IIT, Madras, etc.)

- ❖ **But disadvantages of MS are:**
- ❖ Increased shrinkage cracks.
- ❖ Reduction in slump.
- ❖ Reduction in retention period.
- ❖ Increased stickiness (difficulties in pumping of concrete).
- ❖ Imported waste product and costly.

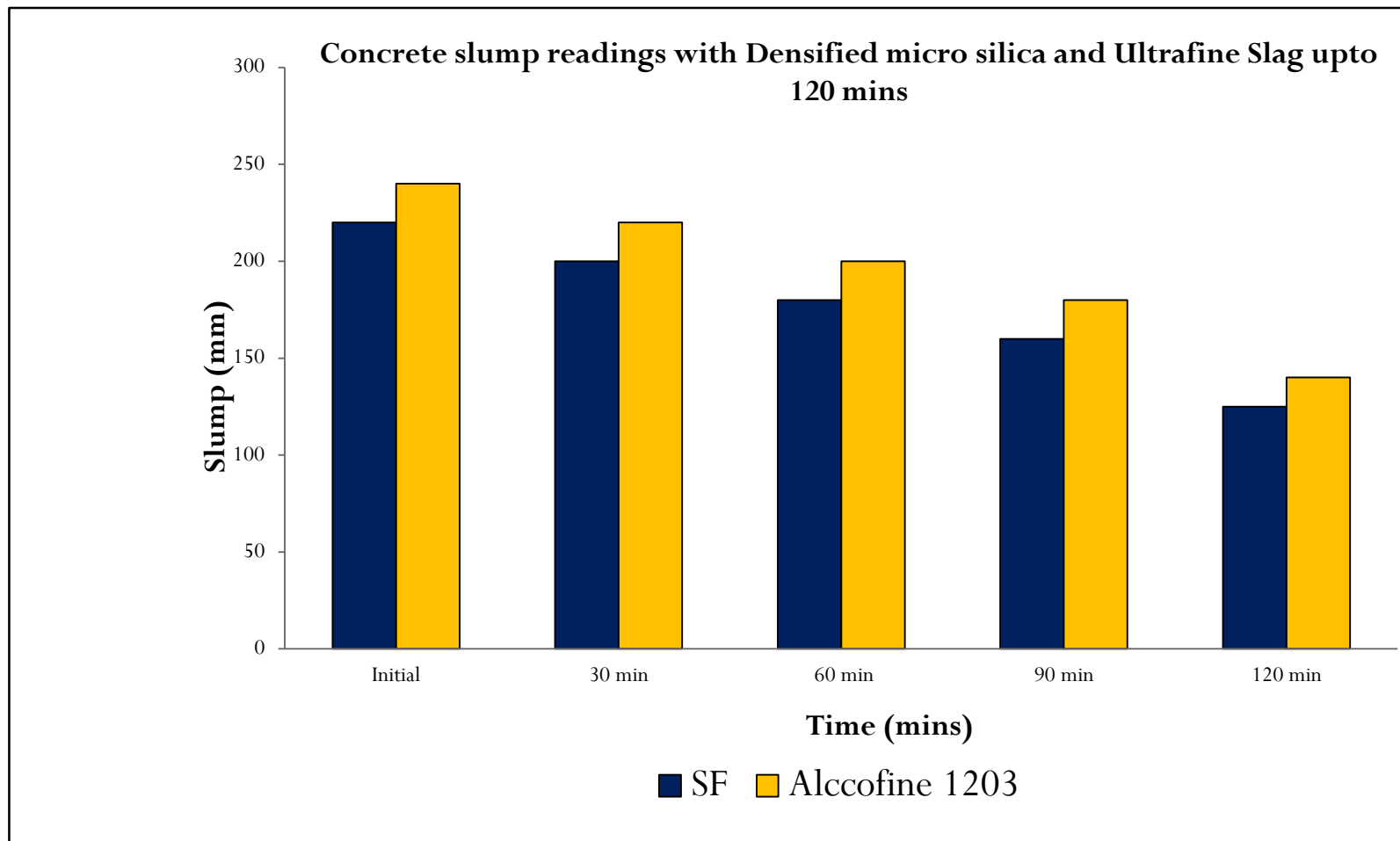


Fig. 1

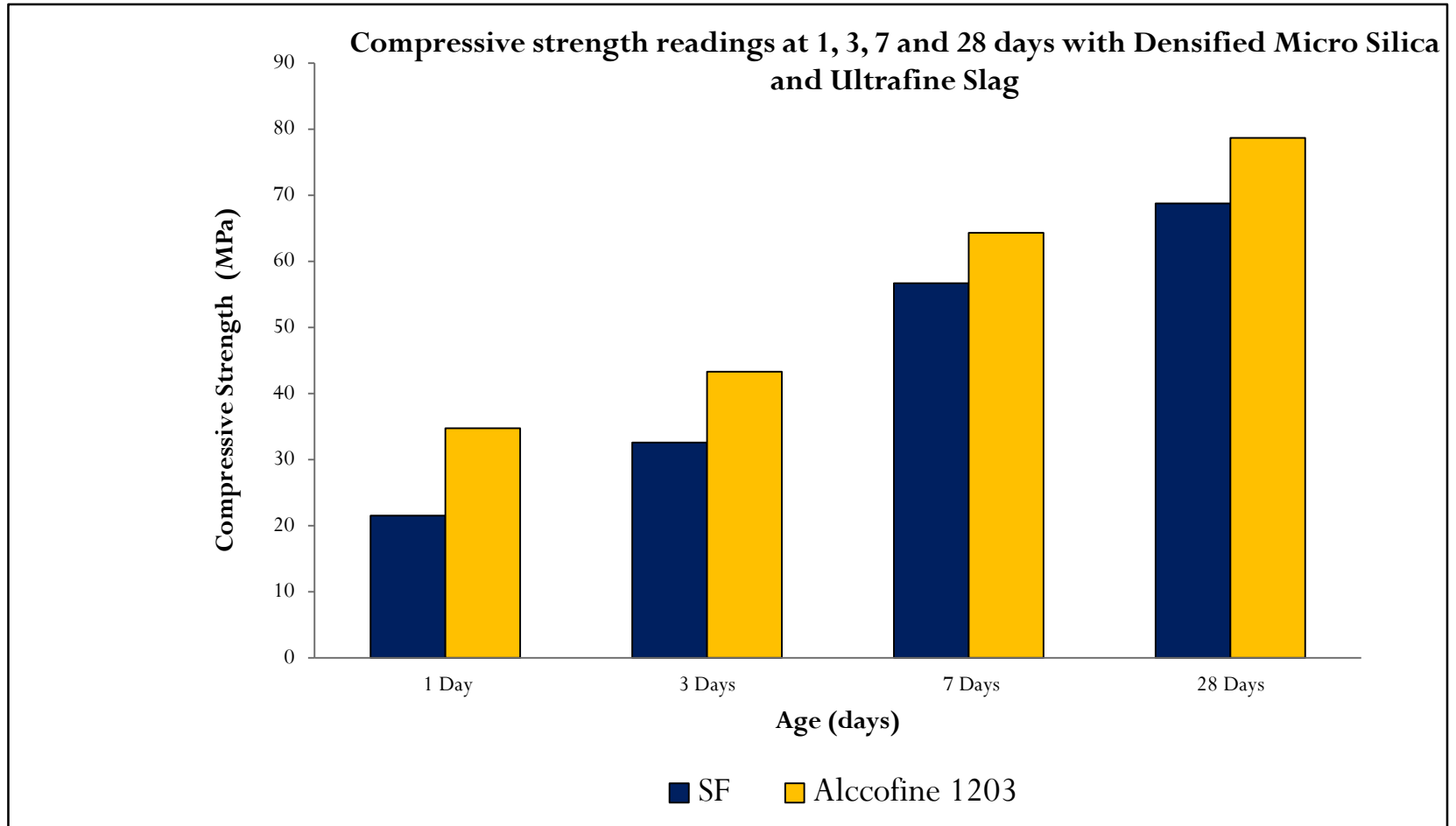


Fig. 2

2.3 Reduction in Cost with Alccofine-1203

❖ Other Advantages of Alccofine-1203

❖ Cost reduction in all grades of concrete.

❖ Example:

❖ Goa Project: Saving in concrete cost using 3% Alccofine-1203 is Rs. 77/cum in M50 concrete with 50% GGBS.

❖ Varanasi Project: Saving in concrete cost with 35% fly ash for different grades of concrete with different percentage of Alccofine-1203 are:

2.4 Reduction in Cost with Alccofine

- ❖ For M50 grade of concrete, saving of **INR 200/cum** with **2.3% Alccofine-1203** .
- ❖ For M40 grade of concrete, saving of **INR 136/cum** with **1.32% Alccofine-1203**.
- ❖ For M35 grade of concrete, saving of **INR 123/cum** with **1.25% Alccofine-1203** .

- ❖ **UTCL Project, Mumbai: Saving in concrete cost using 3.3% Alccofine 1203 is **INR 160.21/cum** in M35 concrete with 50% FA.**
- ❖ **UTCL Project, Mumbai: Saving in concrete cost using 3.03% Alccofine 1203 is **INR 205.9/cum** in M40 concrete with 48.4% FA.**
- ❖ **India Bulls Project, Panvel (Mumbai): Saving in concrete cost using 3.77% Alccofine 1203 is **INR 500/cum** in M50 concrete with FA 20%.**
- ❖ **L & T ECC Infra & Bridges, Faridabad: Saving in concrete cost using 4.86% Alccofine 1203 is **INR 201.77/cum** in M55 concrete with no FA.**

- ❖ **Hex World, Navi Mumbai: Saving in concrete cost using 8.51% Alccofine 1203 is INR 40/cum in M60 concrete with 50% FA.**
- ❖ **In an experimental Standard Mix: Saving in concrete cost using 8.47% Alccofine 1203 is INR 153.40/cum in M80 concrete with 13.55% FA.**
- ❖ ***For M50 Grade of Concrete, saving in concrete cost using 2.5% Alccofine 1203 is INR 119/cum. (Noida Project)**
- ❖ ***For M40 Grade of Concrete, saving in concrete cost using 2.7% Alccofine 1203 is INR 72.8/cum. (Noida Project)**

*** Note: Original Mix Design was with OPC 53 Grade Cement which was replaced by PPC and Alccofine 1203. Instead of PPC, OPC and Fly Ash would have increased the cost benefit. However site went with PPC as they did not have additional silos required for Fly Ash. Please note that per kg of cost of OPC and PPC is the same Rs 6/ kg.**

2.5 Cost Reduction in Concrete with Alccofine-1203 Vs. Micro silica

- ❖ Studies at IIT, Bhubaneshwar (P. Dinakar, 2010) show:
 - ❖ M100 concrete- Saving **INR 763/cum** with UFS (15%) against SF (15%)
 - ❖ For M110 grade of concrete- Saving **INR 1389/cum** with UFS (30%) against SF (30%)

2.5 Reduction in Cost with Alccofine-1203

In short,

Use UFS in all concrete for

- More durable concrete
- More economical concrete
- Easy pumpable concrete

Eliminate use of micro silica.

2.6 : Triple Blended Concrete

- ❖ Composite concrete is permitted (SCMs upper limit 65%)
- ❖ We should aim for 35% OPC, 35% Fly Ash, 30% GGBS
Part of GGBS can be replaced by UFS.

(IS:16415-2015)

This way, we can produce more durable, more economical and easily pumpable concrete.

2.7 : 40 mm MSA

- ❖ Use 40 mm MSA for all foundations including piles, pile caps, substructures including pier caps.
- ❖ Use 125 mm (5") concrete pipeline for pumping.

3.0: Prescriptive vs. Performance Based Specifications:

- ❖ Generally we adopt prescriptive specifications.
- ❖ Developed countries are slowly moving towards performance based specifications.
- ❖ India is also very slowly moving, at much lower speed, towards performance based specifications.

What are the main Basic Requirements of Performance Based Specifications for Concrete?

a) Strength

b) Impermeability

4.0 Permeability Tests on Concrete:

Various Commonly Adopted Tests:

- RCPT
- RCMT
- DIN
- Salt Ponding

4.1 RCPT-

- Most widely specified.
- Normally permissible value < 1000 coulombs @ 56 days.
- Becomes easy quality tool as testing takes only few hours (about 6 hours)
- Was generally developed for concrete with silica fume.
- In any case, does not indicate migration of chloride into concrete.
- As per the ACI, the chloride penetrability of concrete with respect to RCPT values are given in Table 1.

Table 1

Charge passed (coulombs)	Chloride Ion Penetrability
> 4,000	High
2,000 – 4,000	Moderate
1,000 – 2,000	Low
100 – 1,000	Very low
<100	Negligible

4.2. RCMT-

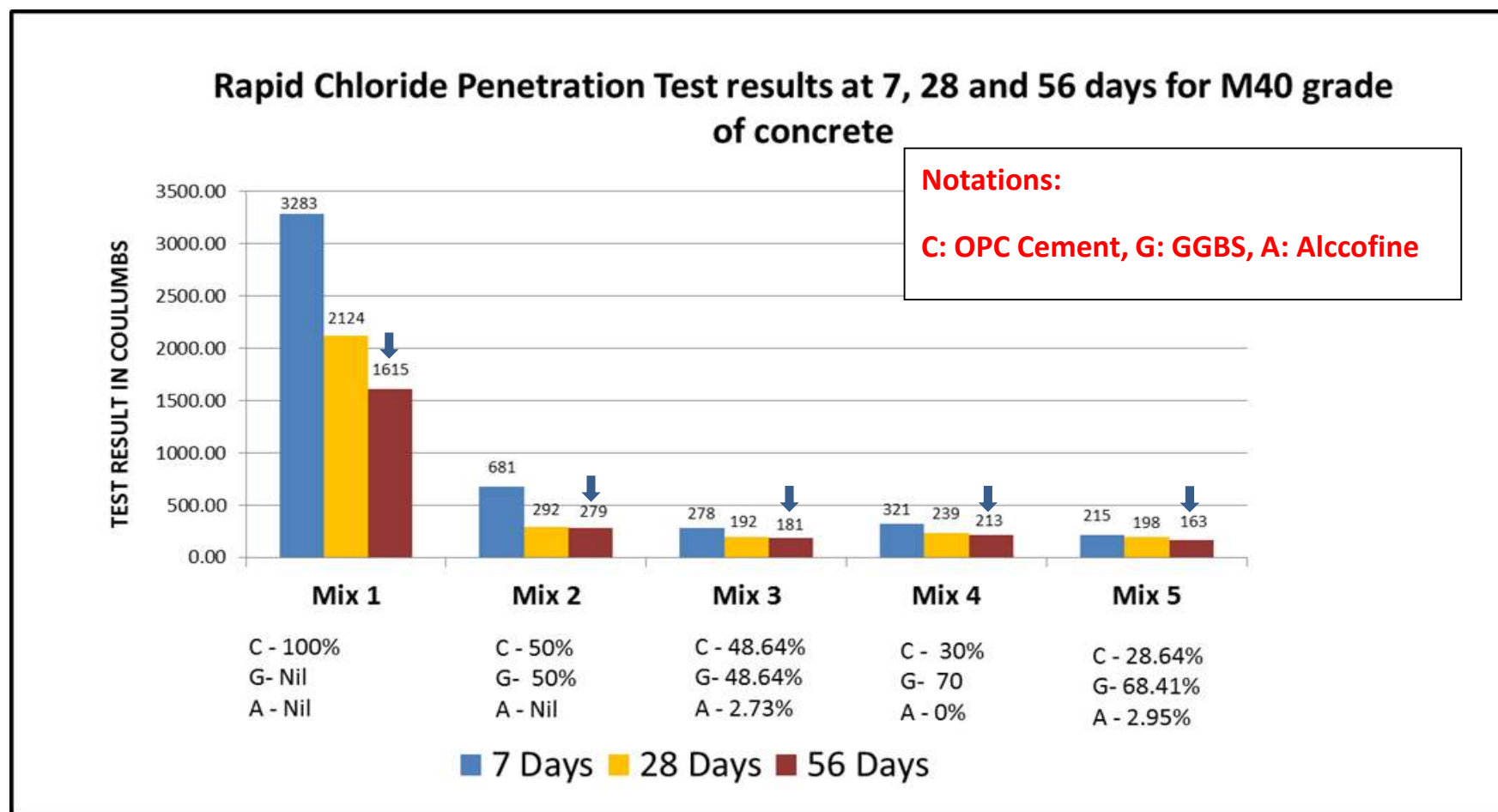
- This test indicates chloride migration into the concrete. Hence more reliable.
- This test is conducted as per the procedure given in NT Build 492 (1999)
- Recently getting specified for some major Indian projects.
- It is very desirable to establish region wise correlation between RCPT and RCMT values till RCMT becomes common test.
- In Table 2 below, correlation between RCPT and RCMT as per ACM is given.

Table 2

Proposed durability performance criteria of a concrete mix based on RCPT and RCMT results		
RCPT (coulombs)	RCMT ($\times 10^{-12} \text{ m}^2/\text{s}$)	Durability performance of a concrete mix
100 to 1000	2 to 8	Excellent (E)
1000 to 2000	2 to 8	Very Good (VG)
2000 to 4000	8 to 16	Good (G)
> 4000	> 16	Poor (P)

5.0 Reduction of Permeability of Concrete:

- Refer Fig.3



6.0 Future R & D Works:

- Effect of Alccofine-1203 on pH value of concrete (fresh and hardened up to one year).
- Effect of fly ash, GGBS, Alccofine-1203 on concrete (fresh and hardened) on pH value up to one year.
- Effect of carbonation resistance of concrete with GGBS as SCM with replacement 50% and 70%, and with fly ash up to 35% replacement, use low w/b ratio close to 0.3.

7.0 Conclusions

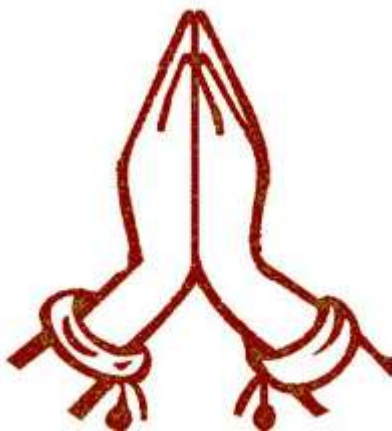
- ❖ In summary, we have to develop innovative mind set.
- ❖ Two “Is” are important for durable, cost effective, speedy and sustainable execution.

i.e.

INNOVATIONS

&

IMPLEMENTATIONS



THANK YOU

