



OCT-30-2023

# Specifications for Today and Tomorrow

# Overview

- Background
- Purpose
- Objectives
- Summary
- Questions





**Jon S. Belkowitz, PhD, PE**  
Chief Executive Officer



**WhitneyLe B. Belkowitz,**  
Chief Technical Officer

# Overview

- Purpose
- Objectives
- Summary
- Questions



# Purpose

Colloidal silica has been gaining traction in the concrete industry to improve durability and extend concrete service-life. The following session will focus on the current and future specifications to guide users in the optimal method to utilize this cutting-edge technology.

Topics will cover the current colloidal silica market and usage, the state of the new specifications for optimal usage, and the future for colloidal silica widespread adoption in the concrete industry.



# Overview

- Objectives
  - Colloidal Silica – Current Usage
  - Current Specifications – ASTM C494
  - Future Specifications – ASTM for Colloidal Silica
- Summary
- Questions



# State of the Industry

## *Why Should We Care*

- On-Going Concrete Problems with Few Viable Solutions
- Limitations on Matured Technologies
- **Colloidal Silica on Concrete Jobsites – ASTM C 494, Type S**



Placement of Concrete with Nano Silica

# State of the Industry

## *Mixing Colloidal Silica in Concrete*

1. Pavements
2. Bridges
3. Driveways
4. Buildings



Placement of Concrete with Nano Silica



# State of the Industry

*Using Colloidal Silica on Concrete*

1. Deteriorated  
Bridges
2. Concrete  
Slabs meant  
for Res.  
Floors
3. Water Tanks

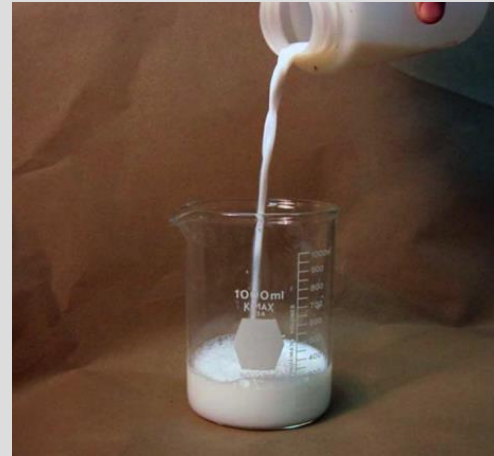


Placement of Concrete with Nano Silica

# Colloidal Silica, Defined

## *Liquid Dispersion of Nano Silica Particles*

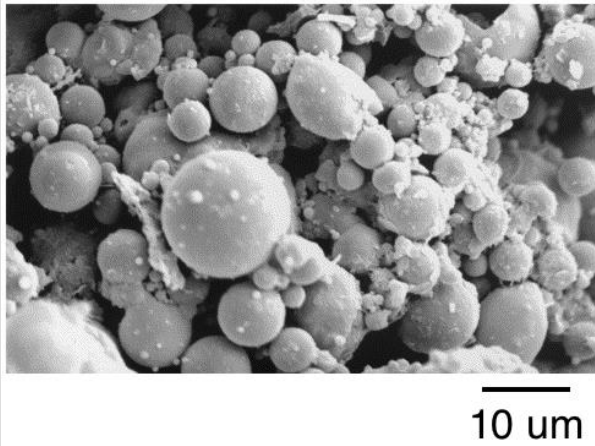
- **Liquid Dispersion**
- **Clear to Milky Appearance**
- **Surface Area – 80 to 500+ m<sup>2</sup>/g**
- **Solids Content – 5 to 50%**



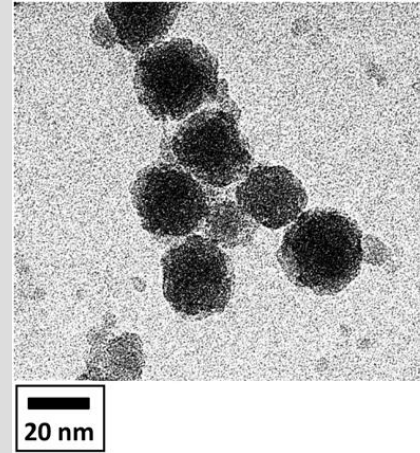
Nano Silica Dispersion

# Enhancing with Newer Technology

*Not Replacing Current Technologies – Enhancing*



• Class F Fly Ash



• Nano Silica

**FOR REFERENCE:**

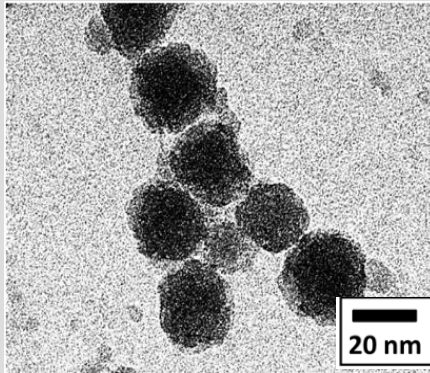
**A strand of hair is approximately 100,000 nm in diameter.**

- Green, B. ACI Materials Journal, SP-254-8, 121–132, 2008.
- Kudyba-Jansen, A., Hintzen, H., Metselaar, R. Materials Research Bulletin, 36, 1215 – 1230, 2001.

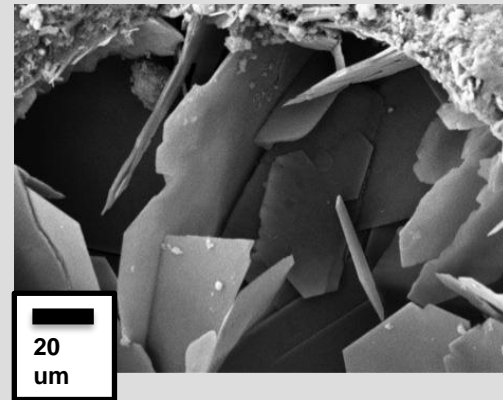
# Pozzolanic Reaction

*And more...*

Colloidal Silica (CS)



Calcium Hydroxide (CH)



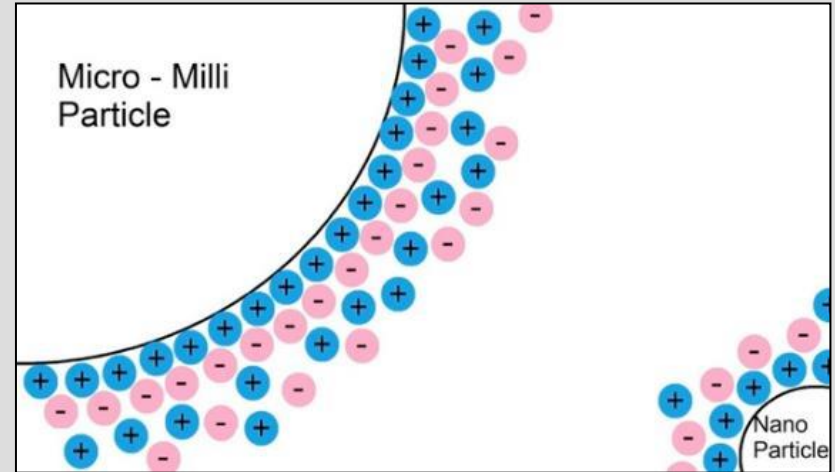
+

1. CS promotes pozzolanic reaction and the development of C-S-H at the expense of CH
2. Particle-to-Particle Packing / Void Filling
3. Creates an environment not conducive to Chemical and Physical Attack

# Colloidal Dispersion of Nano Silica

*What is so special about a Nano Silica?*

1. Free Silica Surface Area  
Pozzolanic Reaction
2. Accelerated Cement  
Dissolution
3. Heterogeneous  
Nucleation



# Overview

- Objectives
  - Colloidal Silica – Current Usage
  - **Current Specifications – ASTM C494**
  - Future Specifications – ASTM for Colloidal Silica
- Summary
- Questions



# ASTM C494

- **ASTM C494 definition:**
  - **“This specification covers the materials and the test methods for use in chemical admixtures to be added to hydraulic-cement concrete mixtures ...”**
- **Type S – Specific Performance Admixtures**

# Current Specification Direction

## ASTM C 494 Testing

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.



Designation: C494/C494M – 19

### Standard Specification for Chemical Admixtures for Concrete<sup>1</sup>

This standard is issued under the fixed designation C494/C494M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

#### 1. Scope\*

1.1 This specification covers materials for use as chemical admixtures to be added to hydraulic-cement concrete mixtures for the purpose or purposes indicated for the eight types as follows:

- 1.1.1 *Type A*—Water-reducing admixtures,
- 1.1.2 *Type B*—Retarding admixtures,
- 1.1.3 *Type C*—Accelerating admixtures,
- 1.1.4 *Type D*—Water-reducing and retarding admixtures,
- 1.1.5 *Type E*—Water-reducing and accelerating admixtures,
- 1.1.6 *Type F*—Water-reducing, high range admixtures,
- 1.1.7 *Type G*—Water-reducing, high range, and retarding admixtures, and
- 1.1.8 *Type S*—Specific performance admixtures.

1.2 Unless specified otherwise by the purchaser, test specimens for qualifying an admixture shall be made using concreting materials as described in 11.1 – 11.3.

NOTE 1—As discussed in Appendix X2, it is recommended that, whenever practicable, supplementary tests be made by the purchaser using the cement, pozzolan, aggregates, air-entraining admixture, and the

ments of this specification. Proof of compliance shall be based on comparisons of the average test results from the batches of test concrete and the average test results from the batches of reference concrete. Admixtures (except for Types B, C, E, and S) shall qualify for provisional compliance if the time of setting, length change, and durability factor meet the physical requirements and any of the alternative compressive strength requirements shown in parentheses in Table 1 are met through the date of provisional acceptance (see Note 4). If subsequent test results at six months or one year fail to meet the requirement of at least 100 % of reference strength, the provisional compliance of the admixture to this standard is withdrawn and all users of the admixture shall be notified immediately. Uniformity and equivalence tests of Section 6 shall be carried out to provide results against which later comparisons shall be made.

NOTE 4—Allowing for provisional compliance while retaining longer term compressive strength requirements promotes more rapid qualification of new materials, but also provides assurance that new admixture technologies will not exhibit unexpected longer term performance. The alternative compressive strength requirements in Table 1 are based on





# ASTM C494

## Concrete Confidence

- **Data for a new product is critical.**
- **Research and development for best possible product**
- **Testing and data for new admixtures - ASTM C494**
- **“Do no harm” test method**

ASTM C494 – Standard Specification for Chemical Admixtures for Concrete, Type S			
ASTM Test	REF	EXP	Specif.
Compression, C 39	✓	✓	- REF
Flexure, C 78	✓	✓	- REF
Time of Set, C 408	✓	✓	- REF
Shrinkage, C 157	✓	✓	- REF
F-T Durability, C 666	✓	✓	- REF
Special Performance	✓	✓	± REF

# Tests Conducted

## *ASTM C 494 Testing – Type S*

- 12+ Month Evaluation that Compares a Conventional Concrete to the SAME Concrete with Colloidal Silica
  - Fresh Properties (C 143, C 231, C 138, C 1064)
  - Time of Set (C 403)
  - Compressive Strength (C 39)
  - Flexural Strength (C 78)
  - Shrinkage (C 157 MOD)
  - Resistance to Freeze/Thaw (C 666)
  - **Abrasion Resistance (C 779)**
  - **Water Sorptivity (C 1585)**
  - **Permeability under Water Pressure (DIN 1048)**
  - **Alkali-Silica Reactivity (C 1567 / C 1293)**

# Overview

- Objectives
  - Colloidal Silica – Current Usage
  - Current Specifications – ASTM C494
  - **Future Specifications – ASTM for Colloidal Silica**
- Summary
- Questions





## New Specification - Colloidal Silica for Use in Concrete

- Focused more on chemical and physical analysis - Uniformity
- Does not focus on Enhanced Performance with Concrete
- Similar to
  - ASTM C618, [Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete](#)
  - ASTM C 1240, [Standard Specification for Silica Fume Used in Cementitious Mixtures](#)

# A New Specification, 09.24

## *ASTM Specifications – A Light At the End of the Tunnel*

### 1. Scope

1.1 This specification covers colloidal silica for use in concrete to **create pozzolanic reactions, or enhance the pozzolanic reactions of other supplementary cementitious materials used in the concrete**, or both, and thereby affect desired concrete properties including strength development and durability.

1.2 The range in required properties provided in this specification encompass the range in properties of commercially available colloidal silica. When using colloidal silica, **the performance achieved in concrete will vary if colloidal silica properties vary, or if colloidal silica is combined with differing amounts, types, and sources of other concrete constituent materials**. Testing with job mixture materials is required to determine performance.

# A New Specification, 09.24

## *ASTM Specifications – A Light At the End of the Tunnel*

**Table 1 Chemical Requirements of the Colloidal Silica**

Sodium oxide (Na <sub>2</sub> O), max % by mass	10.0
Potassium oxide (K <sub>2</sub> O), % by mass	report only
Water-soluble alkali content, max % by mass	1.0
Water-soluble chloride, % by mass	report only
pH, max	10.8
<i>Uniformity Requirements</i>	
Sodium oxide, potassium oxide, water-soluble alkali content, Water-soluble chloride, variation allowed from manufacturer's stated content, percentage points	0.05
pH variation allowed from manufacturer's stated content, points	0.5

# Overview

- Purpose
- Objectives
- **Summary**
- Questions



# Summary

- Objectives
  - Colloidal Silica – Current Usage
  - Current Specifications – ASTM C494
  - Future Specifications – ASTM for Colloidal Silica





# Overview

- Purpose
- Objectives
- Summary
- **Questions**



[Contact Us](#)

**QUESTIONS**

**Thank  
You!**

