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Federal Highway Administration
Turner-Fairbank Highway Research Center

The Use of Electrical Durability Tests on Concretes with CS

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Source: FHWA.

Purpose

- Investigation 1: Determine if inclusion of commercial CS products in concrete mixtures affects electrical durability test methods differently than nonelectrical test methods.
- Investigation 2: Evaluate durability of concrete mixtures using raw CS products with different surface areas and amounts.
- Investigation 3: Measure autogenous shrinkage of various technologies, including CS, LWA, SRA, and latex.

Investigation 1

Electrical Durability Testing of Concretes with Commercial CS Projects

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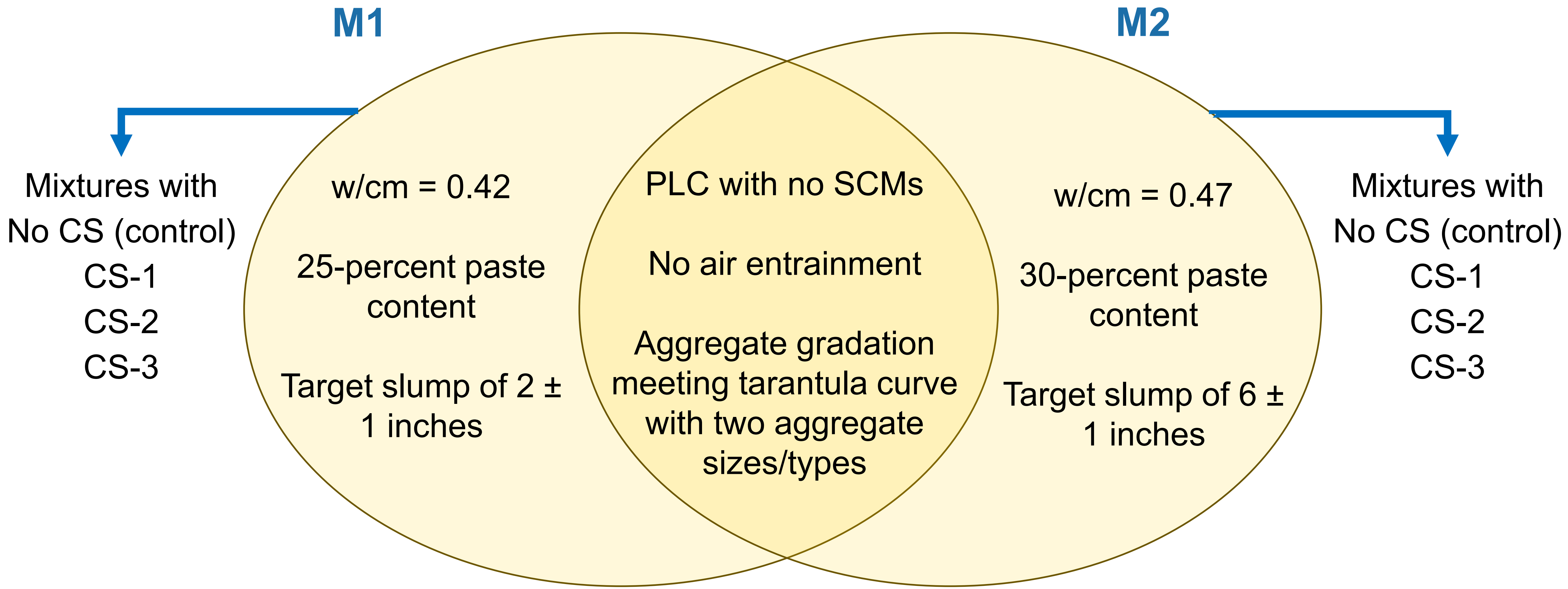
Mixture Overview



Source: FHWA.

Test Matrix

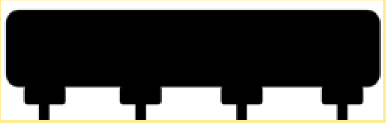
- **Admixture Properties**
  - Solids Content
  - Conductivity
  - Specific Gravity
- **Characterization**
  - Isothermal Calorimetry
- **Concrete Fresh Properties**
  - Slump
  - Total Air
  - Unit Weight
  - Temperature
  - Box Test
- **Concrete Mechanical Performance**
  - Compressive Strength (ASTM C39[3]):
    - 1 d
    - 28 d
    - 56 d
- **Concrete Durability Performance**
  - BR (modified AASHTO T 402[4]):
    - 1 d
    - 3 d
    - 28 d
    - 56 d
  - SR (AASHTO T 358[5]):
    - 1 d
    - 3 d
    - 28 d
    - 56 d
  - Chloride Migration (NT Build 492[6]): 56 d
  - Chloride Diffusion (ASTM C1556[7]): 56 d
  - Porosity

Source: FHWA.

Electrical Versus Physical Tests

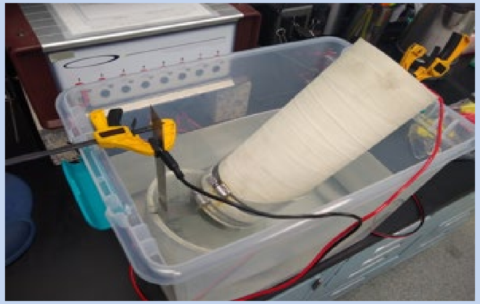
Electrical Tests

Apparent SR(5)



BR(4)

Semielectrical Tests



Chloride migration coefficient(6)

Physical Tests

Chloride diffusion coefficient(7)

Porosity

All figures source: FHWA.

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Materials Dosage

The **highest** recommended dosages suggested by the manufacturers were used for all of the commercial products.

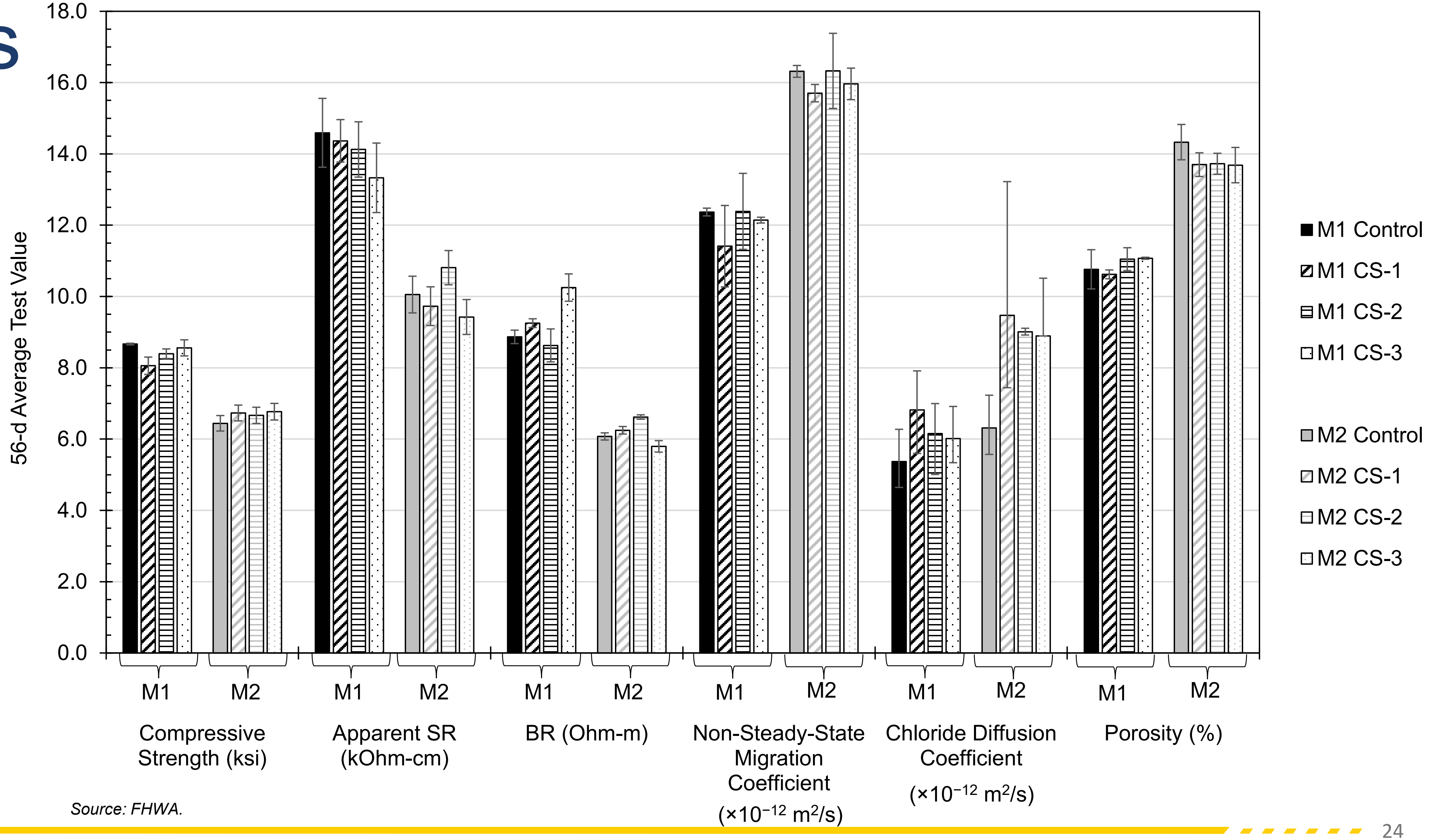
Materials	Manufacturer Recommended Dosage
CS-1	8–**20** fl oz per cwt
CS-2	4–**8** fl oz per cwt
CS-3	0.5–**1.5 percent** by weight of total cementitious materials content

Admixture Conductivity

The admixtures containing CS were not highly conductive.

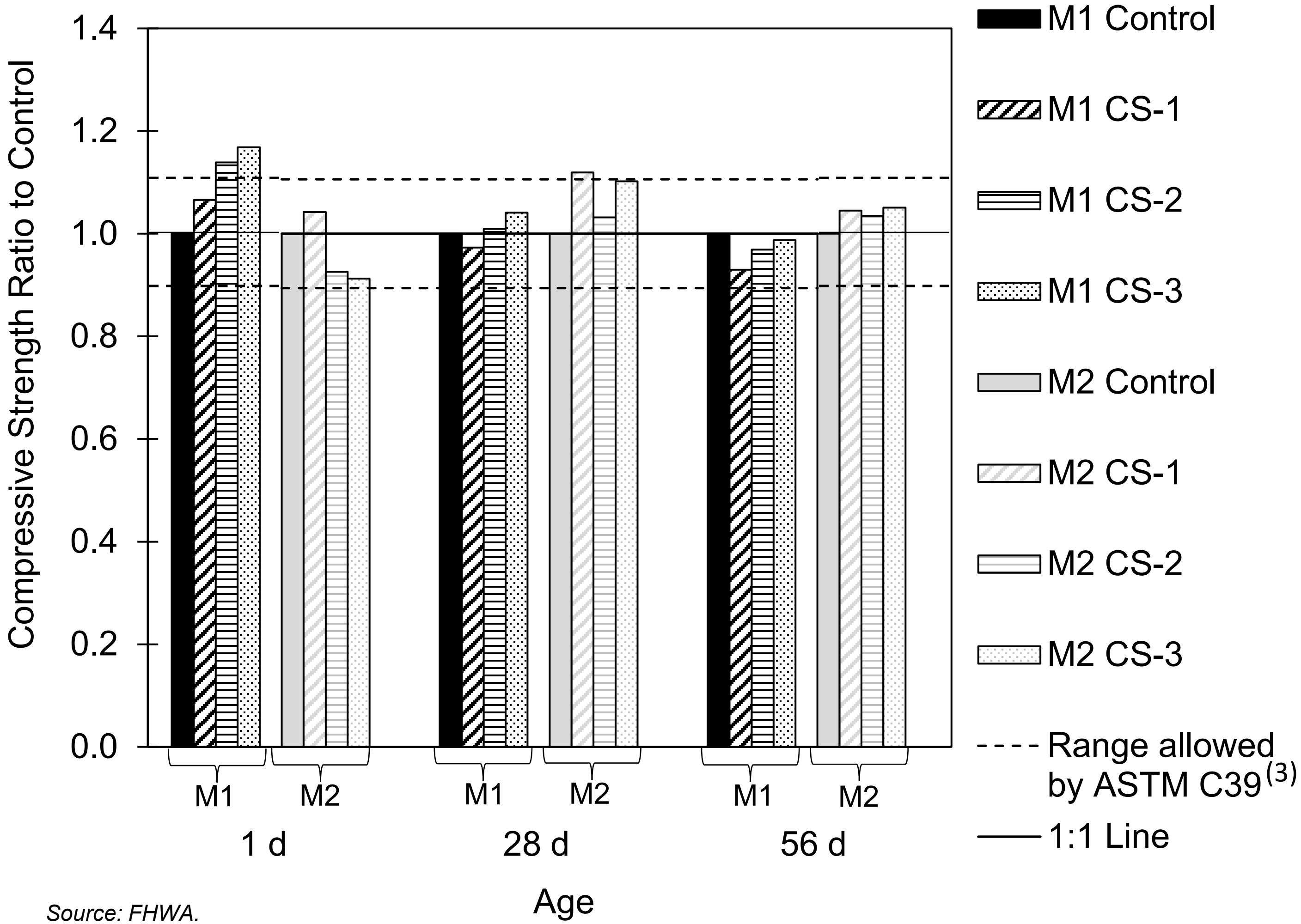
Materials	Conductivity (µS/cm)
CS-1	3,862 at 22.2 ℃
CS-2	2,580 at 22.0 ℃
CS-3	7,164 at 21.5 ℃
Limewater conditioning solution	12,100 at 23.0 ℃
Alkali–concentrated conditioning solution from AASHTO T 402[4]	92,700 at 23.0 ℃

Results



Source: FHWA.

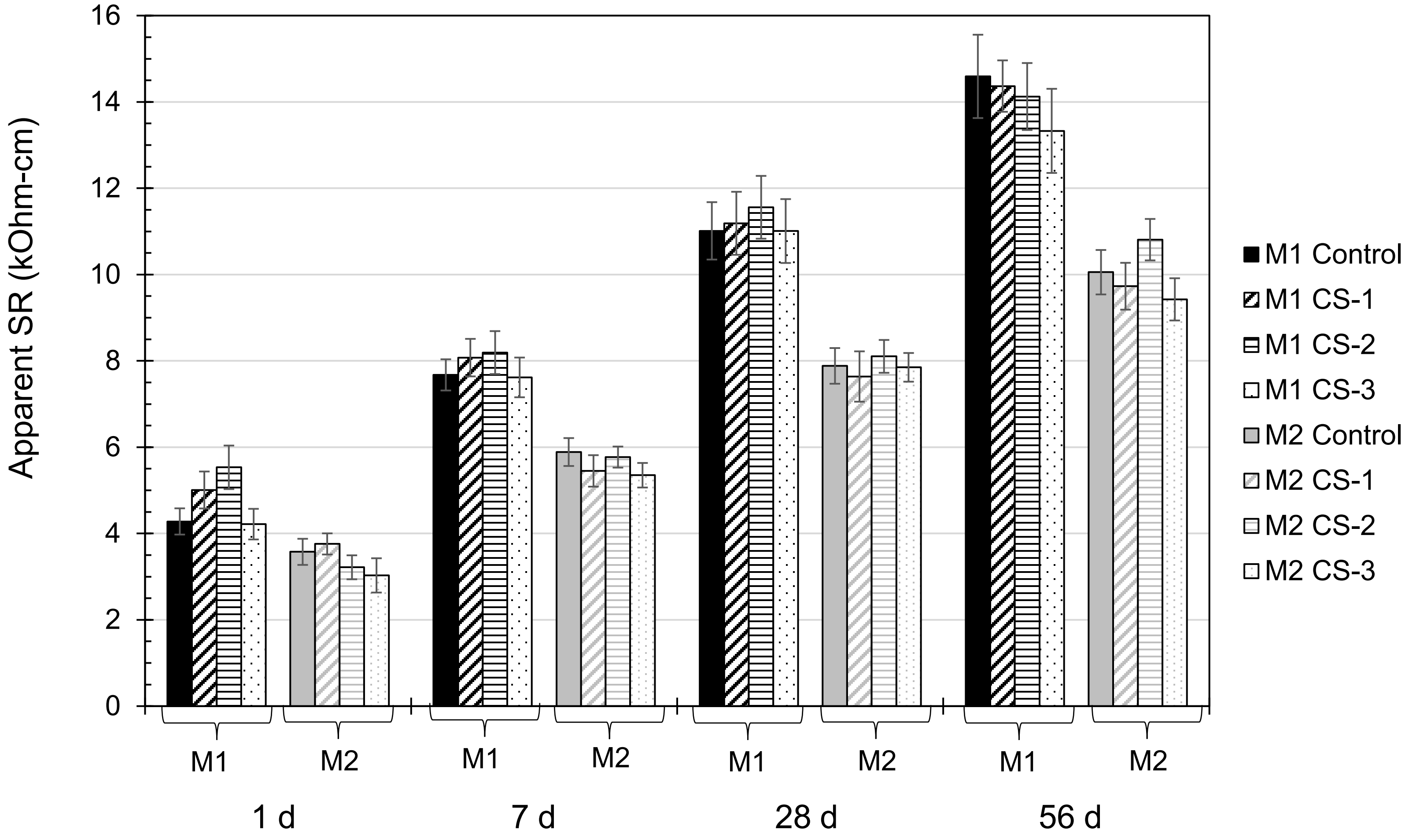
Compressive Strength Normalized



Source: FHWA.

- The compressive strengths of CS samples are within range of control samples.
- CS may increase compressive strength at 1 d for M1 with lower w/cm.
- CS has less influence on strength for M2 with higher w/cm.
- There is not a significant difference between control samples and samples with CS at 56 d.

Apparent SR

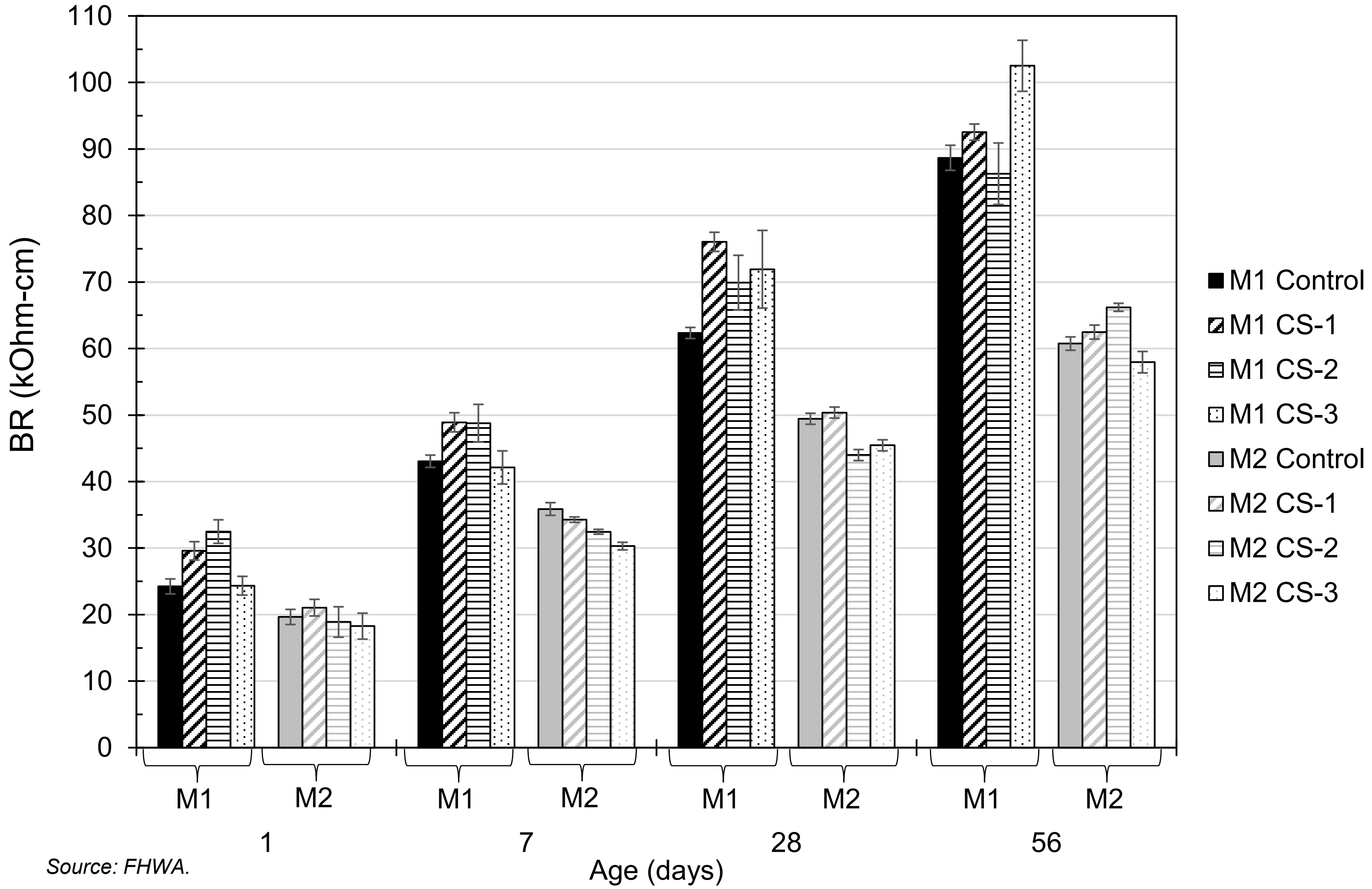


The apparent SR is not significantly different for the control samples without CS compared to those with CS after very early ages.

The apparent SR is higher for the M1 samples than for the M2 samples.

Source: FHWA.

BR



Source: FHWA.

- The BR of concrete with lower w/cm is more affected by the inclusion of CS.
- The M1 concrete samples have higher resistivity than the M2 concrete samples with or without CS.

Investigation 2

Durability for Concretes with Raw CS Products

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Mixture Identification

M2

- PLC with no SCMs
- No air entrainment
- Aggregate gradation meeting tarantula curve with two aggregate sizes/types
- w/cm = 0.47
- 30-percent paste content
- Target slump of 6 ± 1 inches

Mixtures

CS surface area

Manufacturers' recommended dosage for using commercial CS products

M2-130-R

M2-228-R

M2-360-R

M2-130-4R

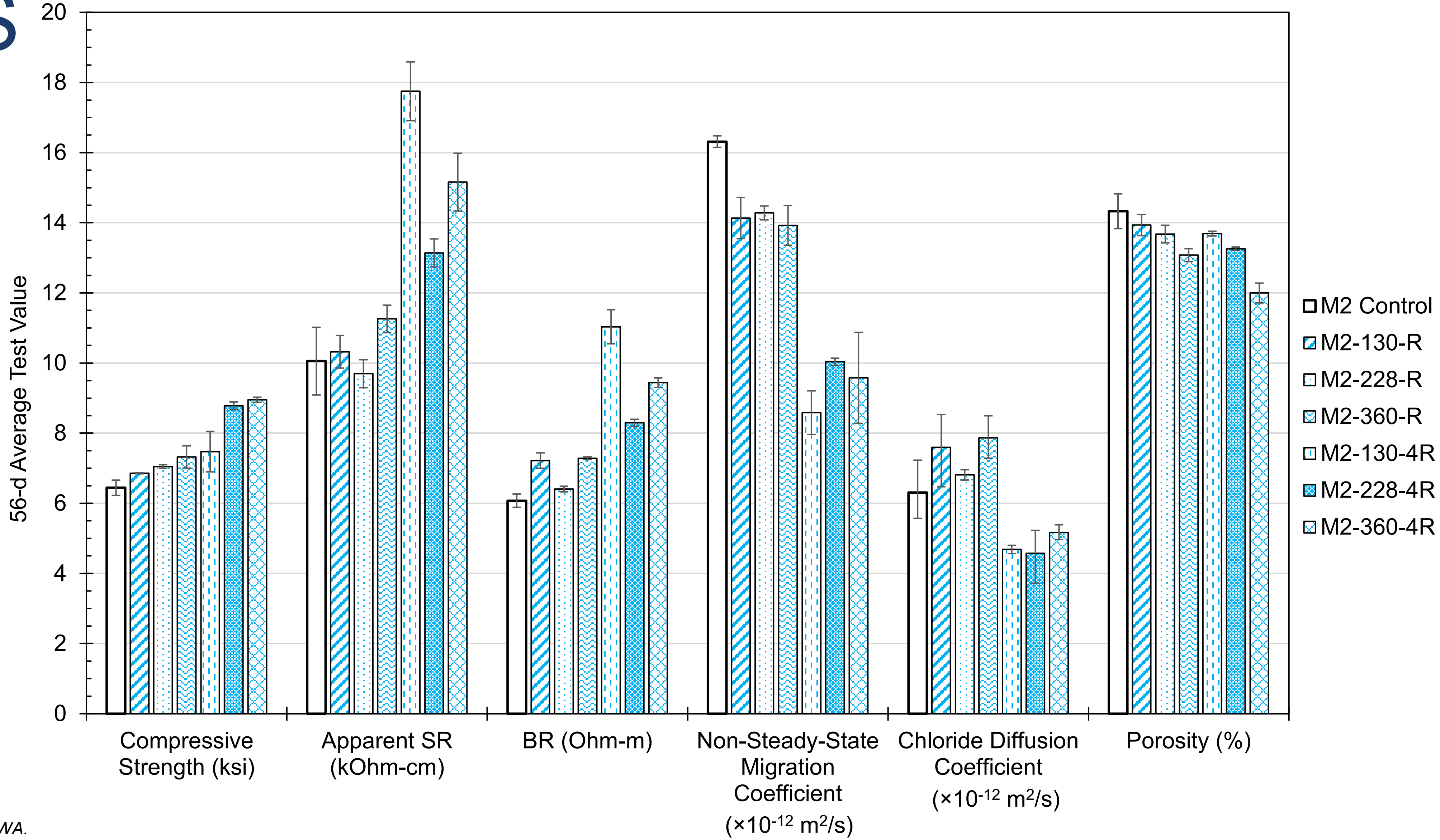
M2-228-4R

M2-360-4R

Four times the manufacturers' recommended dosage for using commercial CS products

Source: FHWA.

Raw CS



Source: FHWA.

Investigation 3

Autogenous Shrinkage

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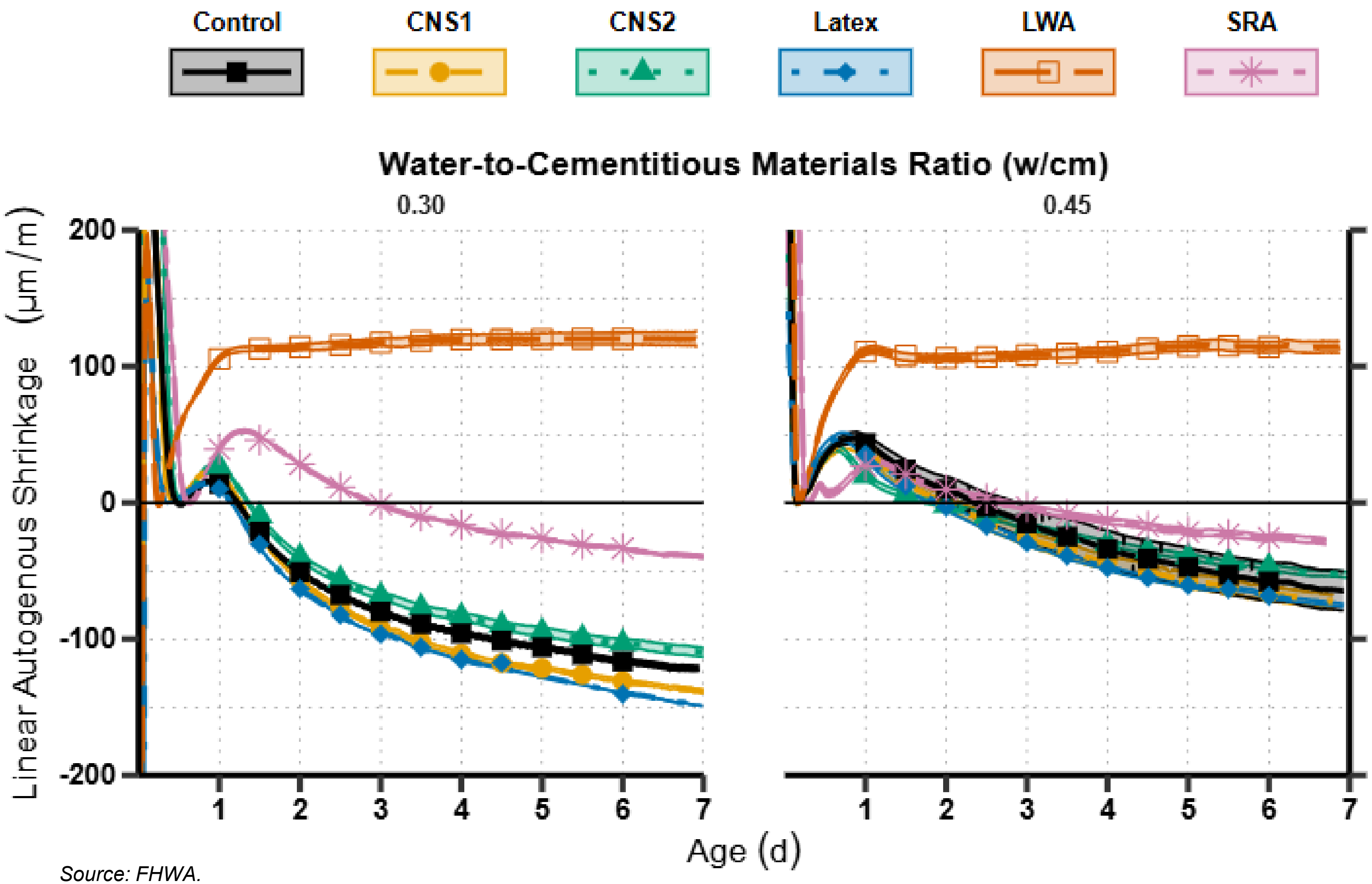
Autogenous Shrinkage



Source: FHWA.

- Internal curing stores water to reduce potential for self-desiccation that leads to autogenous shrinkage.
- LWA shows no autogenous shrinkage.
- SRA shows expansion and then shrinkage.
- CNS, latex, and control show similar autogenous shrinkage.

Key Takeaways

- Electrical tests can be used to indicate durability of concretes containing commercial CS products when used within the manufacturer's recommended dosages.
- If the owner is concerned about using electrical durability tests, bulk chloride diffusion can be performed to indicate transport of ions through the concrete.
- Commercial CS products do not reduce autogenous shrinkage.
- Suggest proper curing practices continue to be employed when placing concretes with CS.
- Suggest concrete durability continue to be improved through mixture design optimization.

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Questions?

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