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# 2024 SPRING CONVENTION

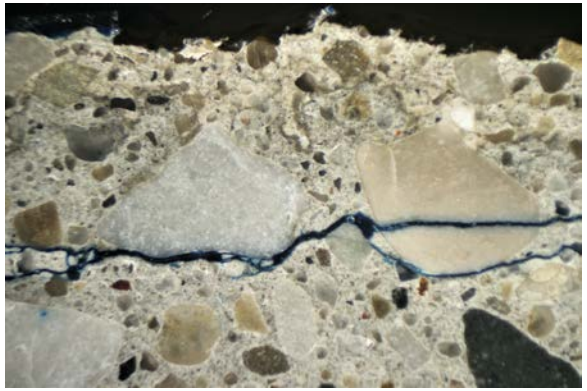
APRIL 21-24, 2024
ICRI.ORG

# Concrete's SALTY SAGA

- Water-soluble vs. Acid-soluble Chlorides
- Method of Testing
- Guidance to Chloride Limits

# What's with all the salty drama?

**WHY?!?!**



# What's with all the salty drama?

- Deicers cause the snow to melt, and they mix to form a brine
- The brine delays freezing but once it gets cold enough, ice will form

- When ice forms, it penetrates into the pores of the concrete so then the ice and concrete move together!


- As more ice forms, brine gets saltier and the concentration of brine gets even higher

**WHY?!?!**

# What's with all the salty drama?

# Another crazy thing about salt

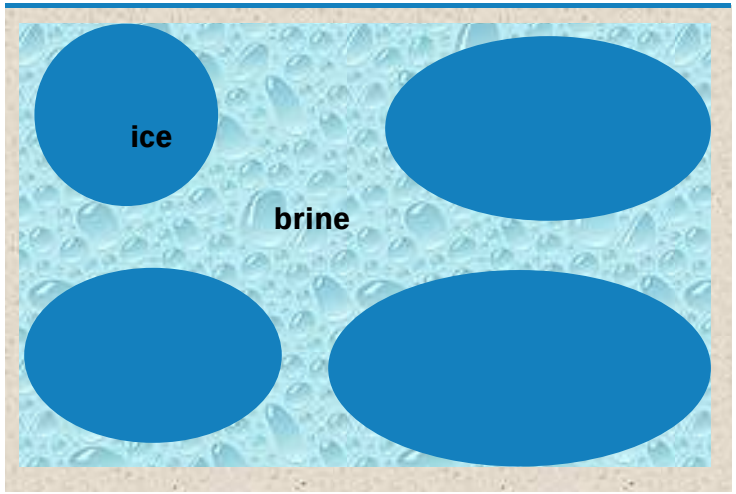
**No Salt = no spalling**

**Moderate Salt = spalling**

**High Salt = no spalling**

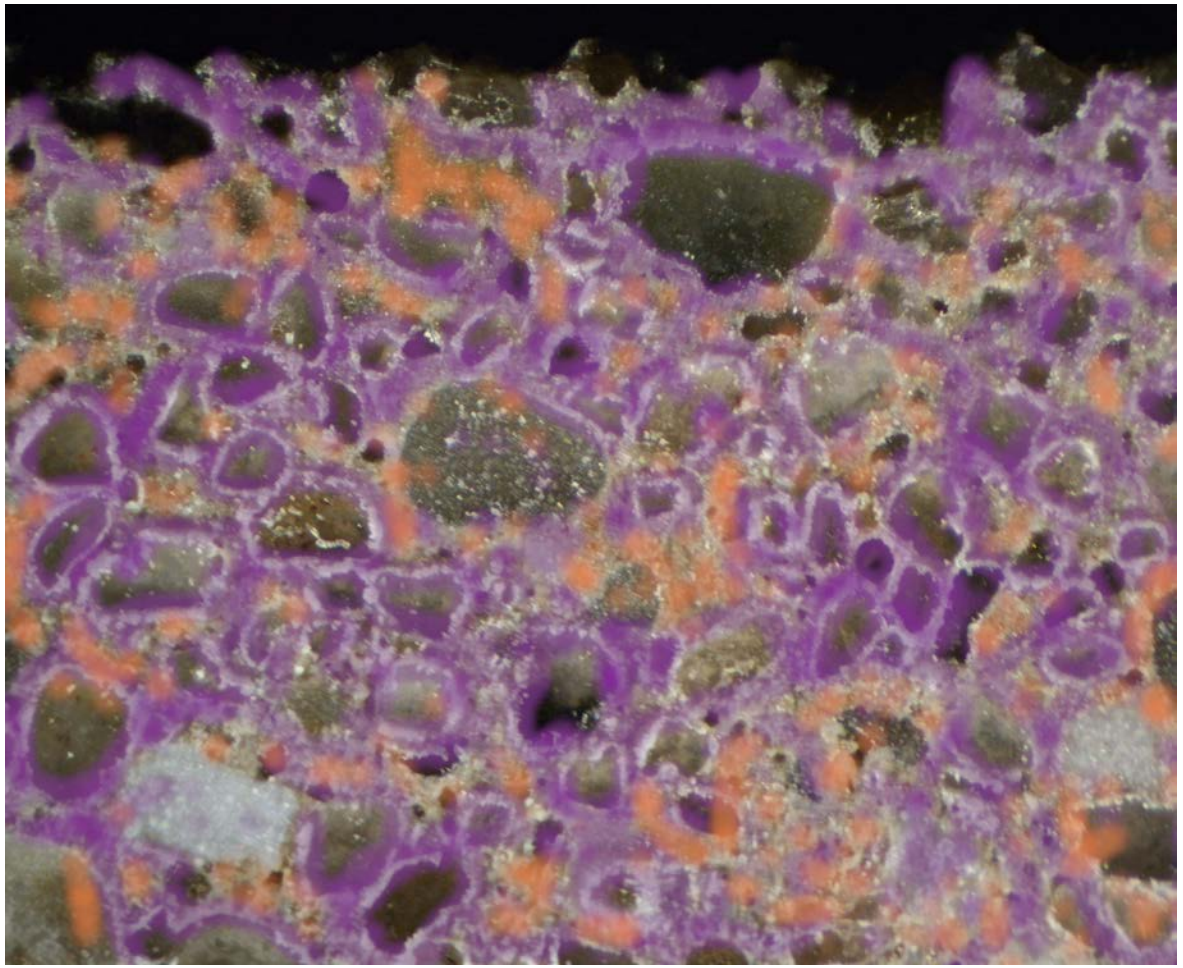
**It doesn't depend on the type of salt!**

**Moderate salt (2%-3%) = damage**




**Lots of salt (> 5%) = no damage**

# What's the difference?

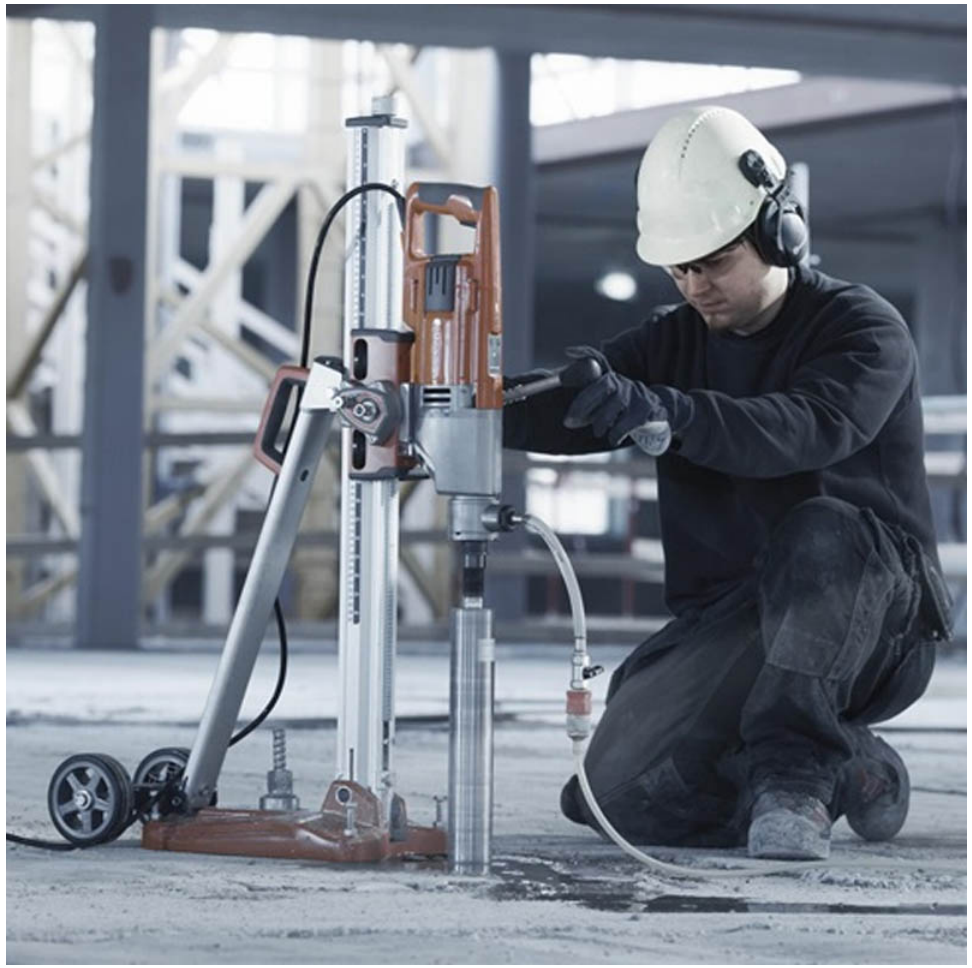


**Free (Water-soluble) chlorides**
**ASTM C1218**

**+ Bound chlorides**

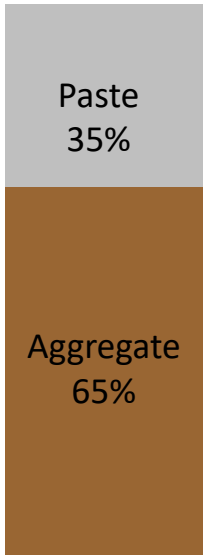
**= Total (Acid-soluble) chlorides**
**ASTM C1152**

# Sample Extraction



# Sampling [rotary impact drill]

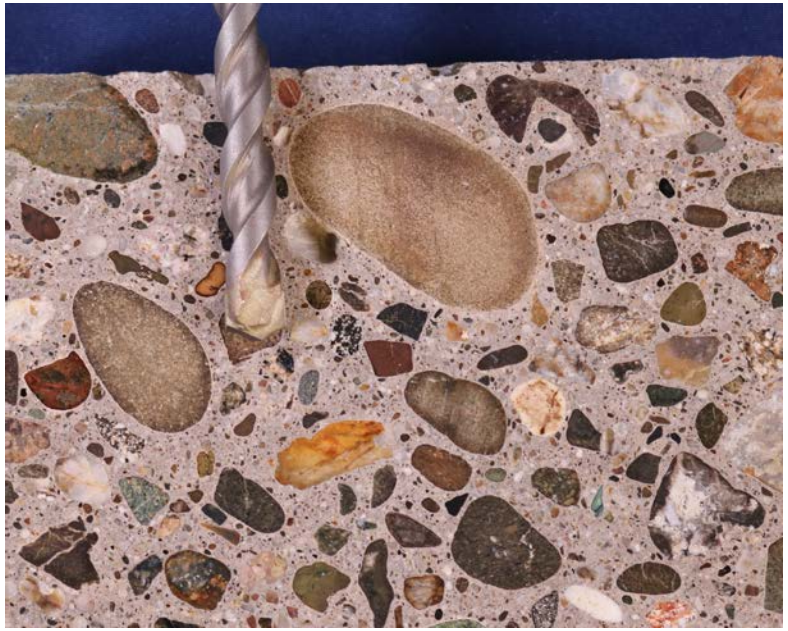
Actual proportions



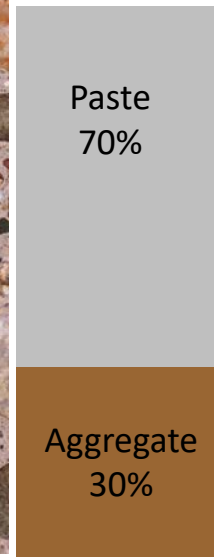

Chloride = 0.2% by weight of cement

Location 1


Chloride results = 0.09% by weight of cement



Location 2

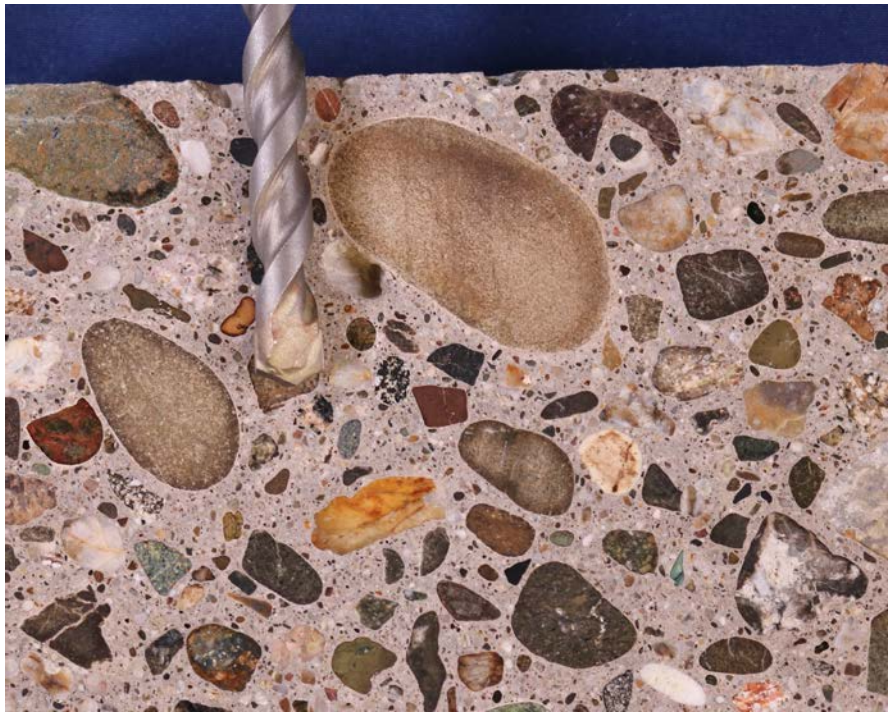



Chloride results = 0.4% by weight of cement

# Sampling [rotary impact drill]

TIPS

- Try to determine the maximum aggregate size (MSA)
- Use a drill larger than the diameter of the MSA. Example:
  1¼” for ¾” MSA
- Collect dust from 4-6 holes closely spaced, combine into one sample.
- WASH your drill bit between locations/depths!
- Do not obtain samples via drilling when aggregates are greater than 1-inch nominal size.

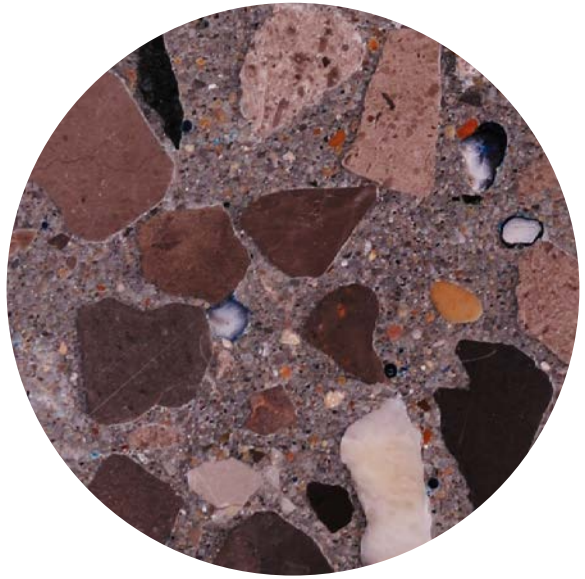


# Sampling [coring]

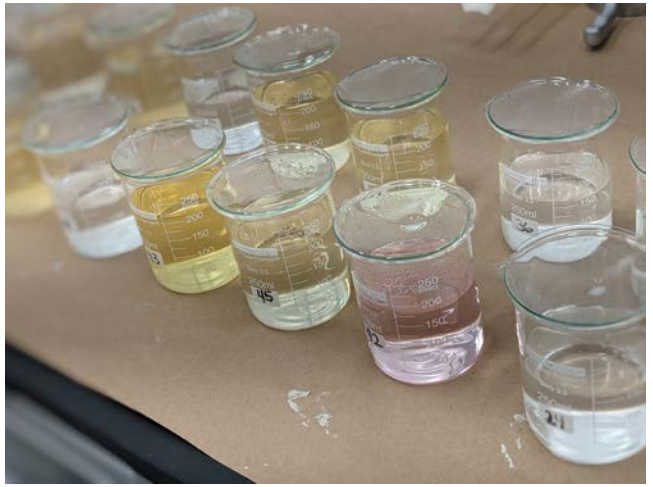
TIPS

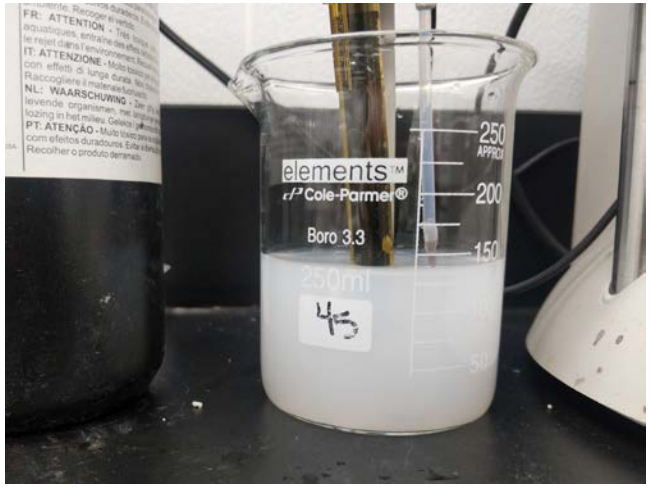
- Follow ASTM C42, diameter of core should be 3x the MSA.
- Wet coring is OK.
- When testing profiles, try to obtain a full depth core to compare top and bottom (exposed vs unexposed) results.
- Thickness matters!
  - ½” slices typically do a good job obtaining a representative sample
  - Use a tile saw
- Obtain mix proportions (if possible) before pulverizing for sanity check. Does the paste/aggregate volume look right?

# Pulverizing




# Test Method




ASTM C1218 → water-soluble chlorides

10 g sample + water → boil for 5 minutes → stand for 24 hours

ASTM C1152 → acid-soluble chlorides

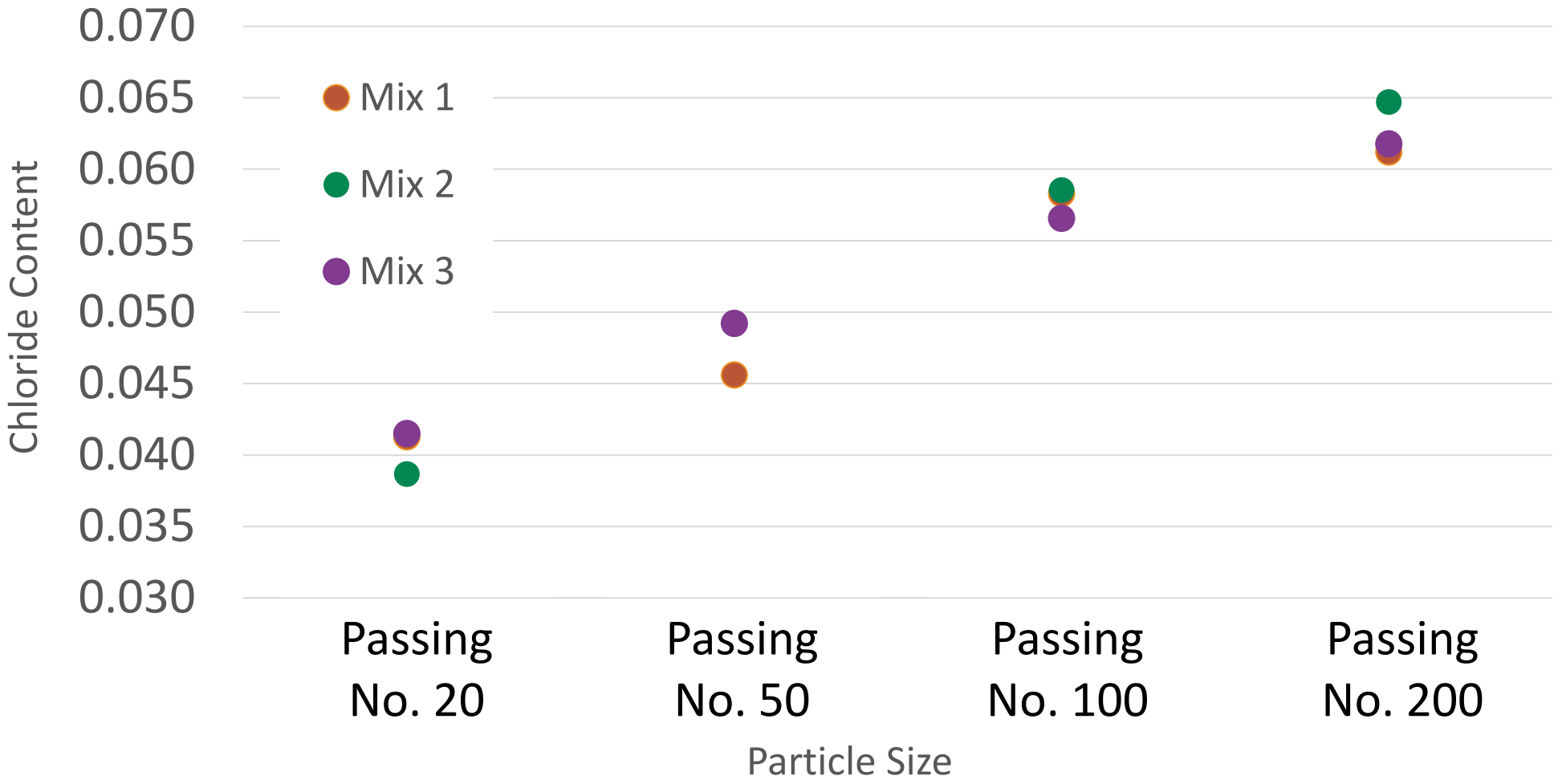
10 g sample + water + nitric acid → boil for 5 minutes

Filter out the residue

Then titrate the solution until the end point is reached.

The chloride content is based on the volume of titrant used.

# Factors that influence results
# Fineness



# ➢ ACI Guidelines/Documents

| Document or Guide | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Category | | | | | | | | | | | | |
| Water Soluble (ASTM C1218) | | | | | | | | | | | | |
| Acid Soluble (ASTM C1152) | | | | | | | | | | | | |

# ACI Guidelines/Documents

## ACI 201.2R Guide to Durable Concrete

| Document or Guide | ACI 201.2R | |
|---|---|---|
| Category | RC in dry or protected conditions | RC in wet conditions |
| Water Soluble (ASTM C1218) | **0.15** | **0.08** |
| Acid Soluble (ASTM C1152) | **0.20** | **0.10** |

# ACI Guidelines/Documents

## ACI 222 Guide to Protection of Reinforcing Steel in Concrete Against Corrosion

| Document or Guide | ACI 201.2R | | ACI 222 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Category | RC in dry or protected conditions | RC in wet conditions | RC in dry or protected conditions | RC in wet conditions | | | | | | |
| Water Soluble (ASTM C1218) | **0.15** | **0.08** | **0.25** | **0.15** | | | | | | |
| Acid Soluble (ASTM C1152) | **0.20** | **0.10** | **0.30** | **0.20** | | | | | | |

# ➢ ACI Guidelines/Documents

**ACI 318 & 301** Building Code Requirements for Structural Concrete and Specifications for Concrete Construction

| Document or Guide | ACI 201.2R | | ACI 222 | | ACI 318 & ACI 301 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Category | RC in dry or protected conditions | RC in wet conditions | RC in dry or protected conditions | RC in wet conditions | Corrosion protection of reinforcement | | | | | |
| Water Soluble (ASTM C1218) | **0.15** | **0.08** | **0.25** | **0.15** | **C0** | **1.00** | | | | |
| | | | | | **C1** | **0.30** | | | | |
| | | | | | **C2** | **0.15** | | | | |
| Acid Soluble (ASTM C1152) | **0.20** | **0.10** | **0.30** | **0.20** | **NA** | | | | | |

# ACI Guidelines/Documents

## ACI 329 Report on Performance-Based Requirements for Concrete

| Document or Guide | ACI 201.2R | | ACI 222 | | ACI 318 & ACI 301 | | ACI 329 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Category | RC in dry or protected conditions | RC in wet conditions | RC in dry or protected conditions | RC in wet conditions | Corrosion protection of reinforcement | | Corrosion protection of reinforcement | | | |
| Water Soluble (ASTM C1218) | **0.15** | **0.08** | **0.25** | **0.15** | **C0** | **1.00** | **C0** | **1.00** | | |
| | | | | | **C1** | **0.30** | **C1** | **0.30** | | |
| | | | | | **C2** | **0.15** | **C2** | **0.15** | | |
| Acid Soluble (ASTM C1152) | **0.20** | **0.10** | **0.30** | **0.20** | **NA** | | **NA** | | | |

# ACI Guidelines/Documents

## ACI 350 Code Requirements for Environmental Engineering Concrete Structures

| Document or Guide | ACI 201.2R | | ACI 222 | | ACI 318 & ACI 301 | | ACI 329 | | ACI 350 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Category | RC in dry or protected conditions | RC in wet conditions | RC in dry or protected conditions | RC in wet conditions | Corrosion protection of reinforcement | | Corrosion protection of reinforcement | | Corrosion protection of metals | |
| Water Soluble (ASTM C1218) | **0.15** | **0.08** | **0.25** | **0.15** | **C0** | **1.00** | **C0** | **1.00** | **EC0** | **0.10** |
| | | | | | **C1** | **0.30** | **C1** | **0.30** | **EC1** | **0.10** |
| | | | | | **C2** | **0.15** | **C2** | **0.15** | **EC2** | **0.10** |
| | | | | | | | | | **EC3** | **0.10** |
| Acid Soluble (ASTM C1152) | **0.20** | **0.10** | **0.30** | **0.20** | **NA** | | **NA** | | **NA** | |

# True or False ??

Water-soluble chloride is less than acid soluble chloride.

## True

Water-soluble chloride generally 75%-80% of the acid soluble chloride.

## True....if

No SCMs (fly ash, slag, etc.)

Limits can be applied to any concrete mix design

## True....but

# Water-Soluble vs. Acid-Soluble

What is the likelihood of corrosion right now?

Determine initial chloride levels for mix design approvals (newly constructed concrete)

What is the likelihood of corrosion in the future?

Determine chloride contents at profile depths

Life cycle analysis

# THANK YOU

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**Connect with me**