

# Preventive Bridge Maintenance – Is the Annual Spring Cleaning Operation Efficient?

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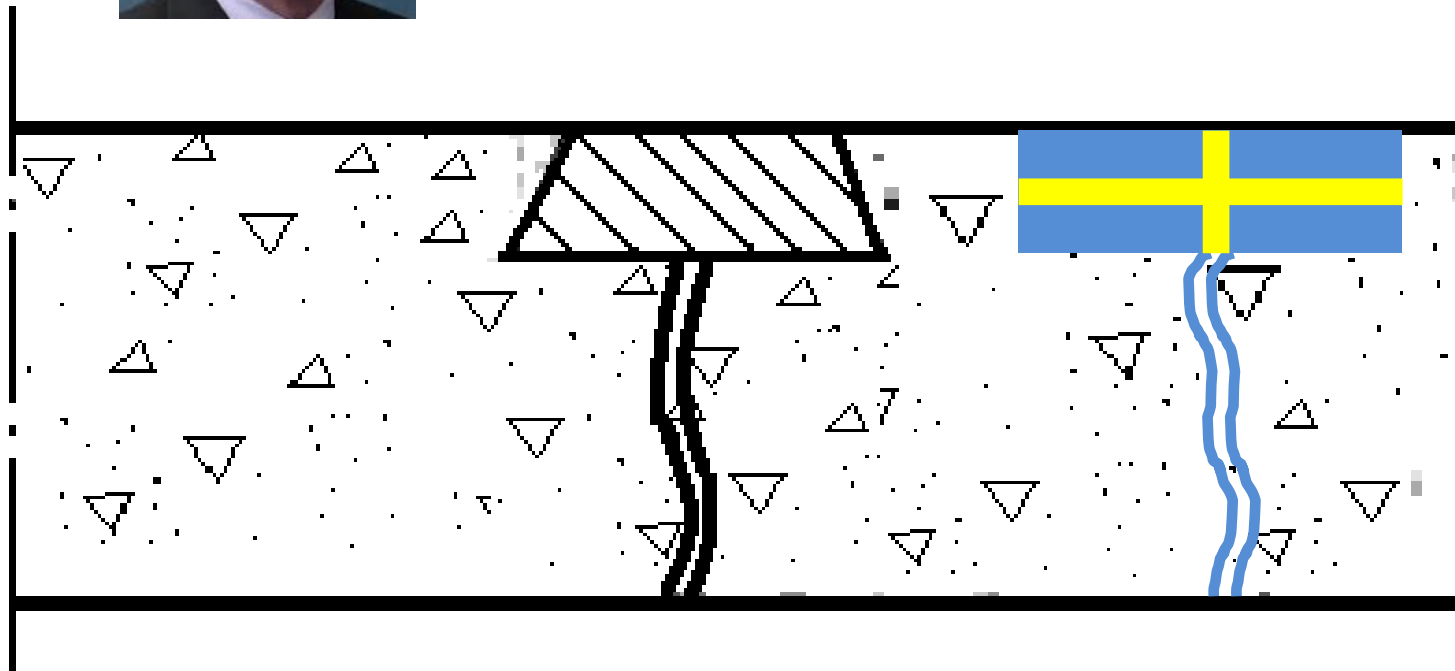
Stockholm, SE, March 26, 2024

Session 2 Honoring Michael M. Sprinkel –  
A Career of Concrete Preservation

# Outline

- Maintenance for improved sustainability
- Swedish conditions
- Preventive bridge maintenance
- Cleaning operation
- Laboratory tests
- Concluding remarks

# Fruitful Discussions on Crack Repair



THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE



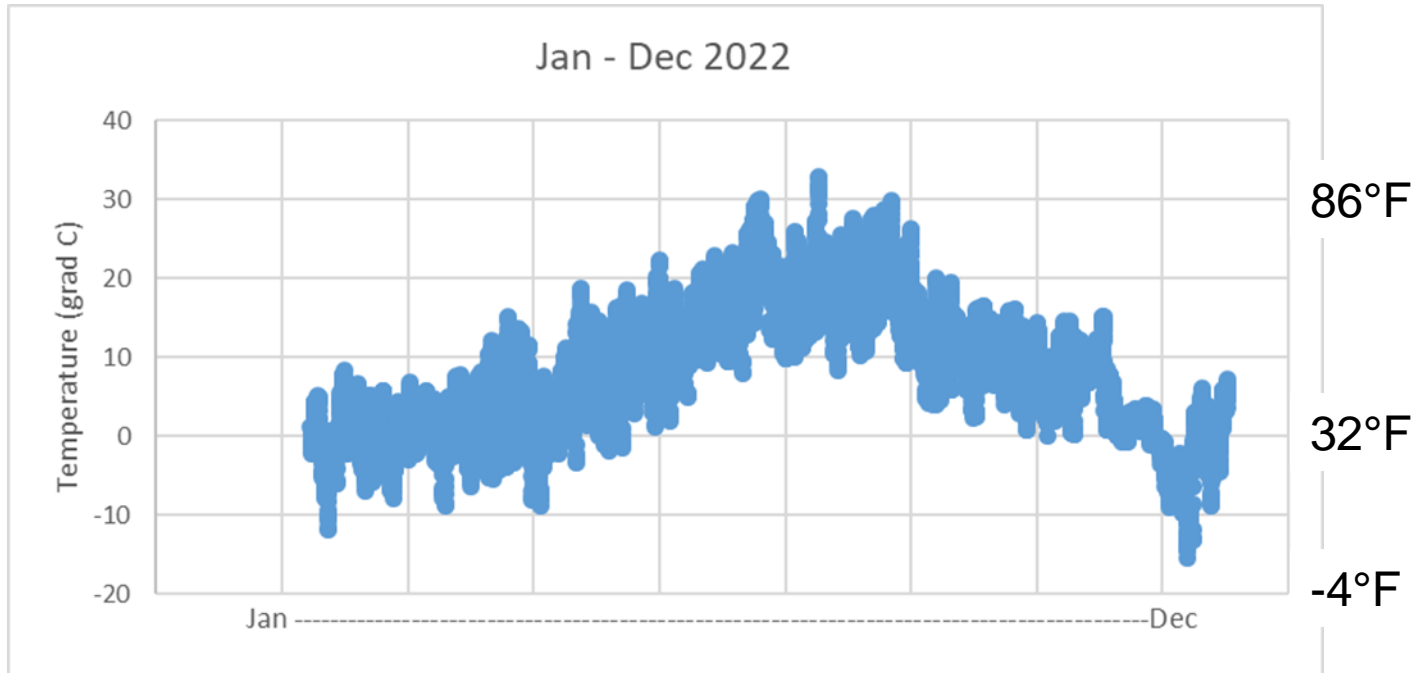
# Historic Perspective

- **100-80 years ago:** Materials expensive – labor inexpensive → optimization
- **60-10 years ago:** Materials cheap – labor expensive → throwaway, simplifications, “one size fits all”, repair & maintenance too expensive
- **Currently:** Materials savings necessary – labor still expensive → optimization & prolongation of use

# Sweden & Stockholm



# Stockholm Weather 2022



267 passes through or touches of 0°C [32°F].



# Extensive Use of De-Icing Salt




# Preventive Bridge Maintenance according to Swedish Transport Administration (STA)

- Cleaning – water flushing
- Secure well-performing drainage
- Eliminate settlements
- Combat vegetation
- Repair railings
- Tighten minor cracks & remedy unevenness on the pavement





A photograph showing a road shoulder next to a metal guardrail and chain-link fence. The ground is covered in dirt and gravel, indicating poor cleaning. The text "Poor cleaning" is overlaid in yellow.

**Poor cleaning**





**Broken drainage**



# Settlement





# Vegetation





**Railing  
deformation**



# How Often Are You Cleaning Your Car?



THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE





# How Often Are You Brushing Your Teeth?



# Water Cleaning according to STA

Year	Requirements
1969	All surfaces of structure are to be kept free of vegetation and contaminants.
1979	Cleaning should be performed after the end of the de-icing period.
1998	Surfaces should be 95% clean of visible contaminants.



# Criticism Regarding "95% clean"

- How do you define "clean"?
- How do you measure cleanliness?
- When should the surface be clean? Always?
- Does not 5% remaining salt lead to reinforcement corrosion in the long term perspective?

# Water Cleaning according to STA

Year	Requirements
1969	All surfaces of structure are to be kept free of vegetation and contaminants.
1979	Cleaning should be performed after the end of the de-icing period.
1998	Surfaces should be 95% clean of visible contaminants.
2013, 2019	Cleaning should be performed with high pressure water (160-200 bar [2300-2900 psi]) from a 150-250 mm [6-10 in.] distance.

Recommended temperature 60 - 90°C [140 - 194°F].

Recommended period: May 15 to July 1.

# Research at KTH



KTH ROYAL INSTITUTE  
OF TECHNOLOGY

Licentiate Thesis in Civil and Architectural Engineering

## Continuous Preventive Bridge Maintenance

Effect of High Pressure Washing on Concrete Bridges

LOUISE ANDERSSON



Stockholm, Sweden 2022

THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE

 **CONCRETE  
CONVENTION**



# Cleaning by Water Flushing



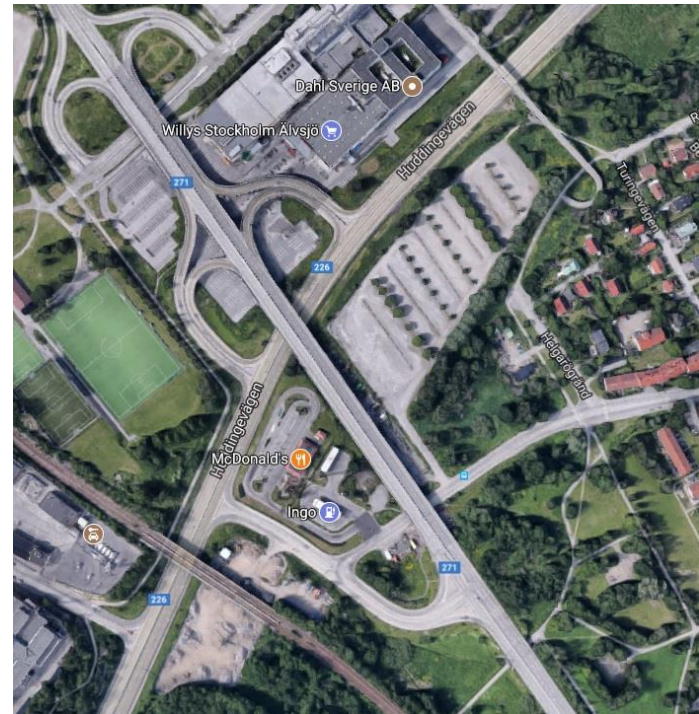
THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE

 **CONCRETE  
CONVENTION**



# Field Tests 1 (2)

- Highway bridge, Stockholm
- Opened for traffic in 1971
- Maintained by City of Stockholm
- Speed limit: 50 km/h [31 mph]
- Moderate traffic
- De-icing salt used during winter (62 times 2017-18)





## Field Tests 2 (2)

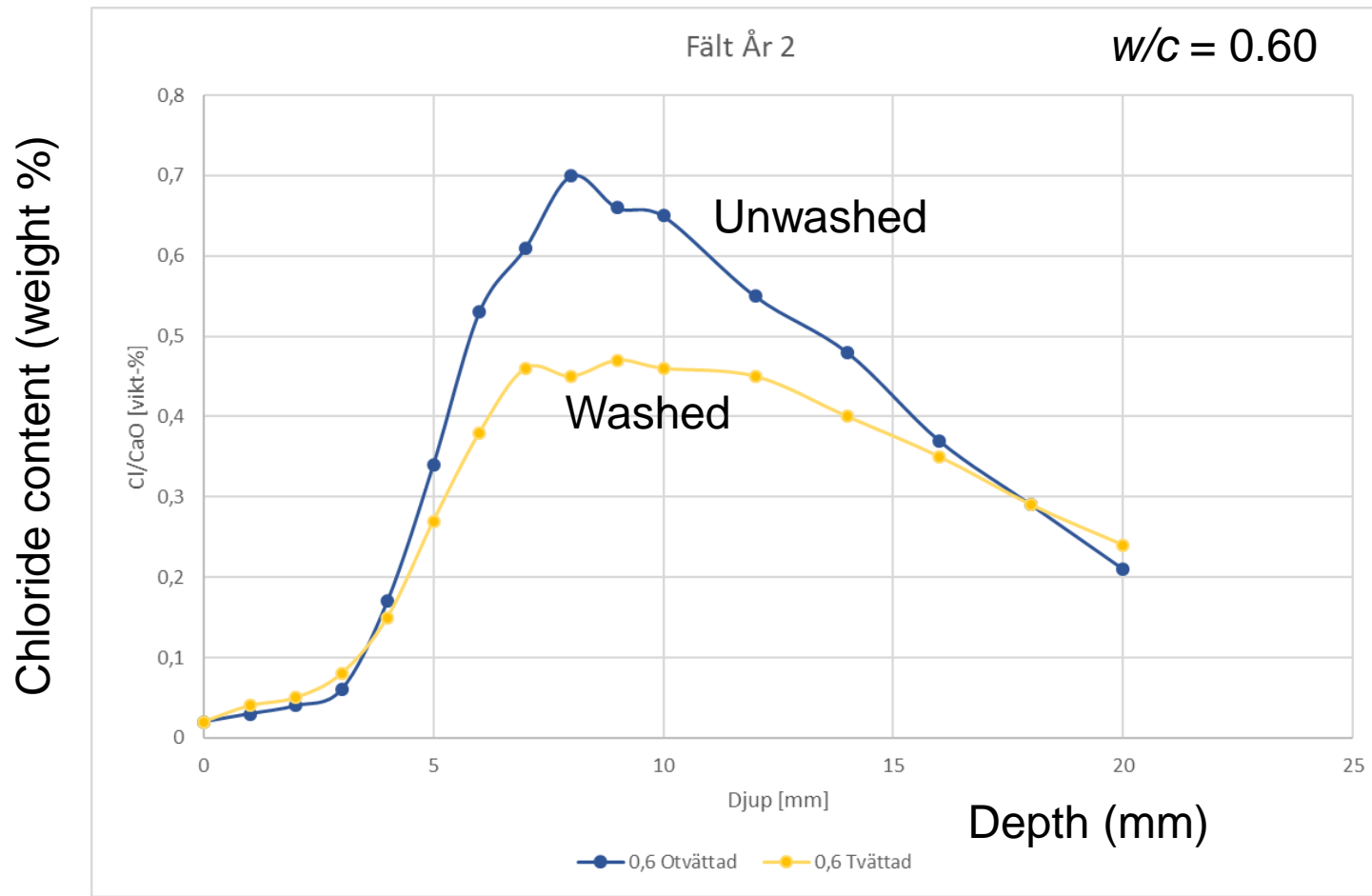
- Start: January 11, 2018
- Two boxes, each with 30 test specimens
- Every box: Two concrete types
- Test variable: Washing or no washing



# Concrete Mixes

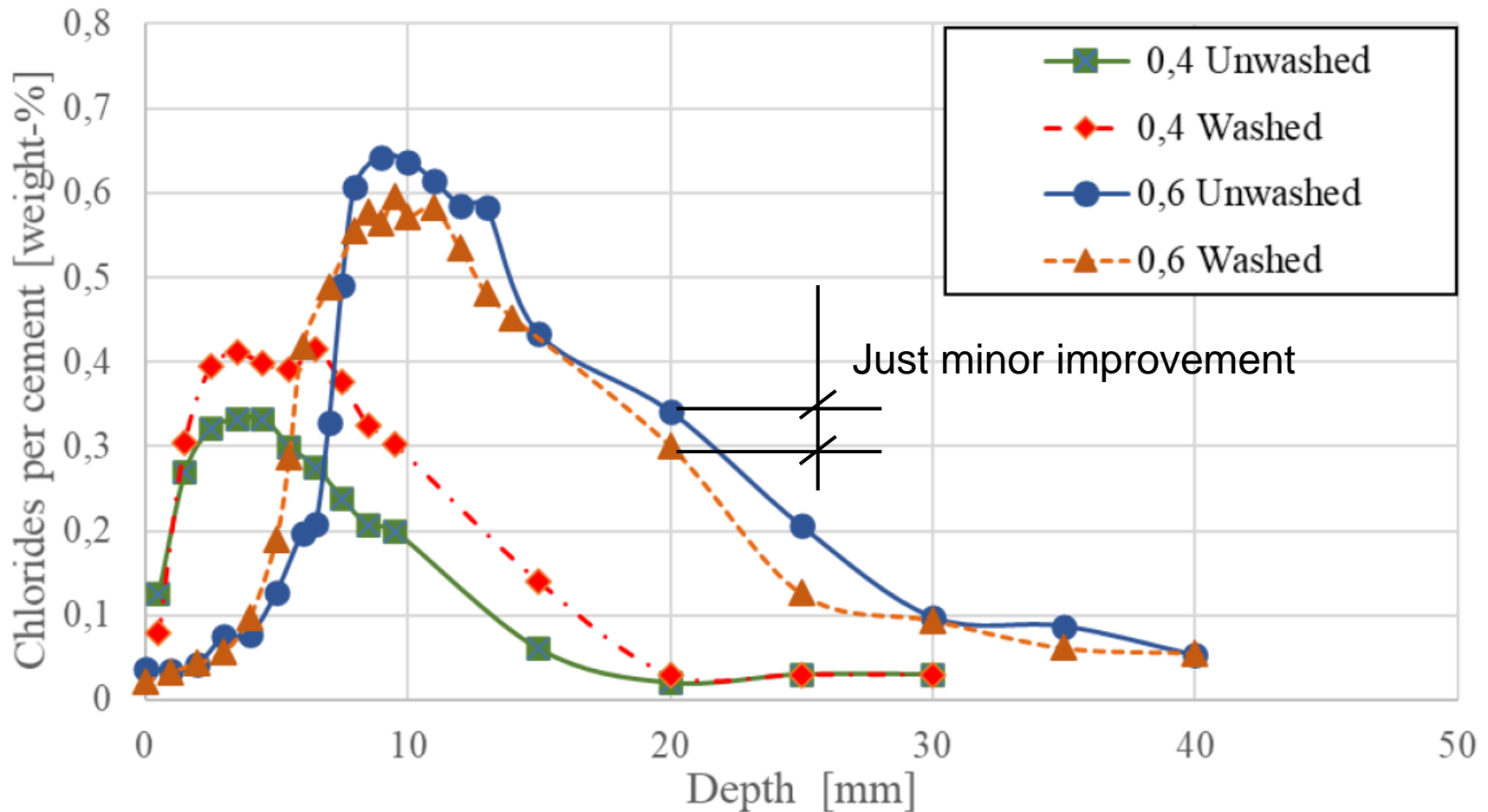
Type of concrete	Old	New
Assumed period	1960s to 1970s	Contemporary (2018)
w/c	0,6	0,4
Cement	CEM I 52,5N (Velox)	CEM I 42,5N (developed for civil engineering structures)
Aggregate	Natural gravel (from glacial period)	Crushed rock
Air content	3,5 %	5 %

# Results after 2 Years





# Results after 3 Years



# Importance of Accelerated Tests

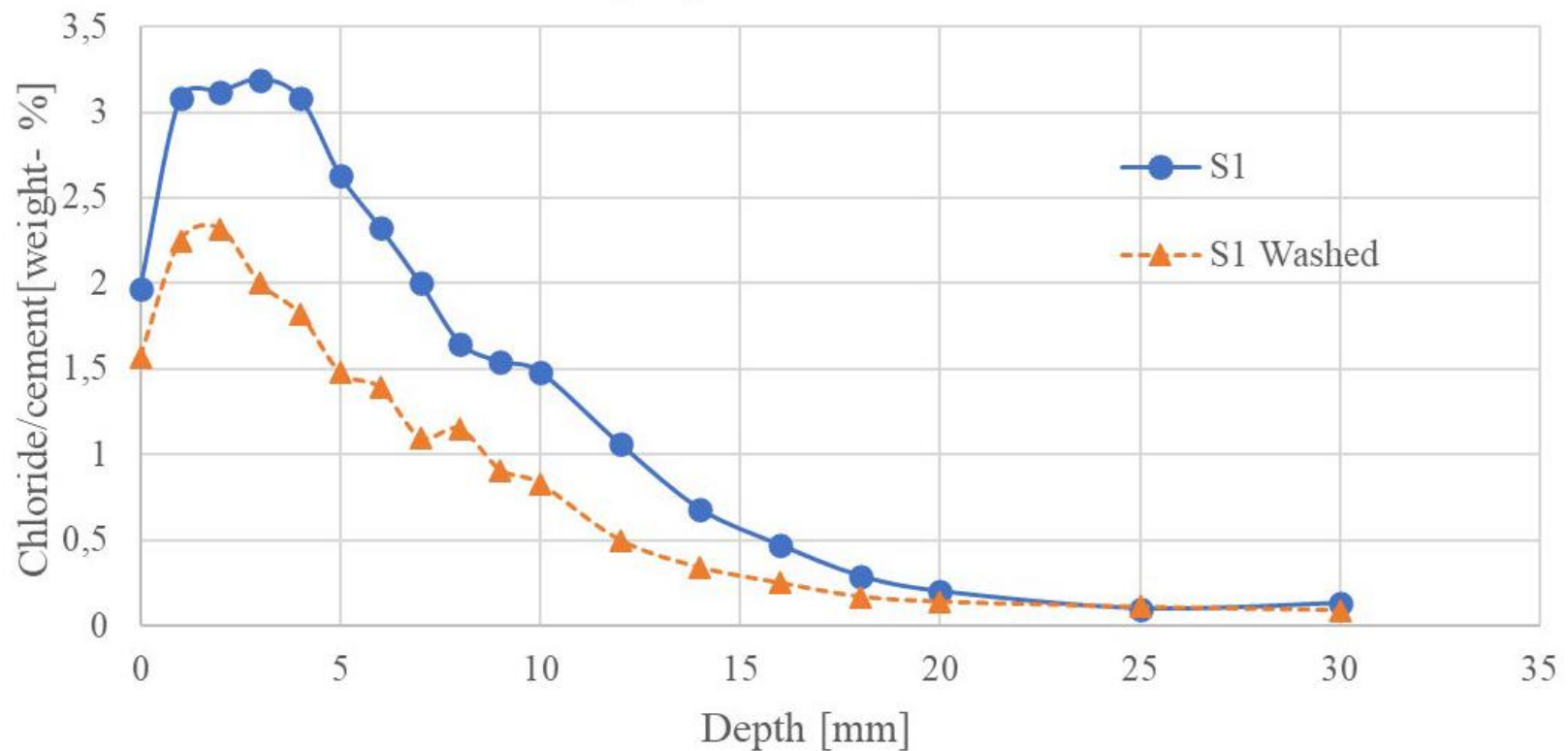
- Chloride ingress is a slow process – we may need to wait for > 10 years for decisive results.
- If cleaning is beneficial – how to make it as efficient as possible?
- Need to study effects of water pressure, water flow, distance between nozzle & surface, water temperature, presence of detergent, concrete quality, etc.
- Field tests expensive → accelerated tests an alternative.

# Development of Accelerated Test Method

"Season"	Winter	Spring	Summer	Fall
Days (No)	1	2	2	2
Temp. (°C) [°F]	4 [39]	20 [68]	40 [104]	20 [68]
RH (%)	100	75	30	85
Washing		Before start		
Type of salt	NaCl			
Salt content (%)	10			

# Results after 8 Cycles (“Years”)

w/c = 0.60



## Concluding Remarks 1 (2)

- The importance of maintenance & repair increases when considering sustainability.
- Preventive bridge maintenance contains several items but cleaning with water flushing may be the most common one.
- The hypothesis is that cleaning reduces chloride ingress and thus postpone reinforcement corrosion.
- Field tests show some support for the hypothesis but no final conclusions can be drawn.

## Concluding Remarks 1 (2)

- An accelerated test method has been developed. It can be used to test a large number of influencing factors.
- Preliminary test results indicate that washing has a greater effect on concrete with  $w/c = 0.6$  than on more durable concrete with  $w/c = 0.4$ .
- → Perhaps, washing could be limited to old concrete bridges (with  $w/c > 0.5$ ).
- More research is needed. The field test ought to be followed several years. The number of unused test specimens is still large.