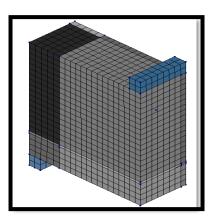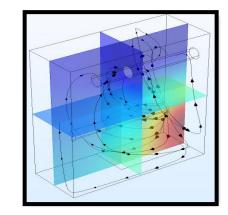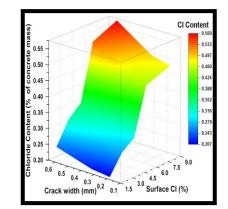# NUMERICAL SIMULATION OF CRACKING EFFECTS AND CHLORIDE CONCENTRATIONS ON CORROSION IN REINFORCED CONCRETE

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OUTLINE

Background and motivations

Chloride content

Corrosion current

Summary

OUTLINE

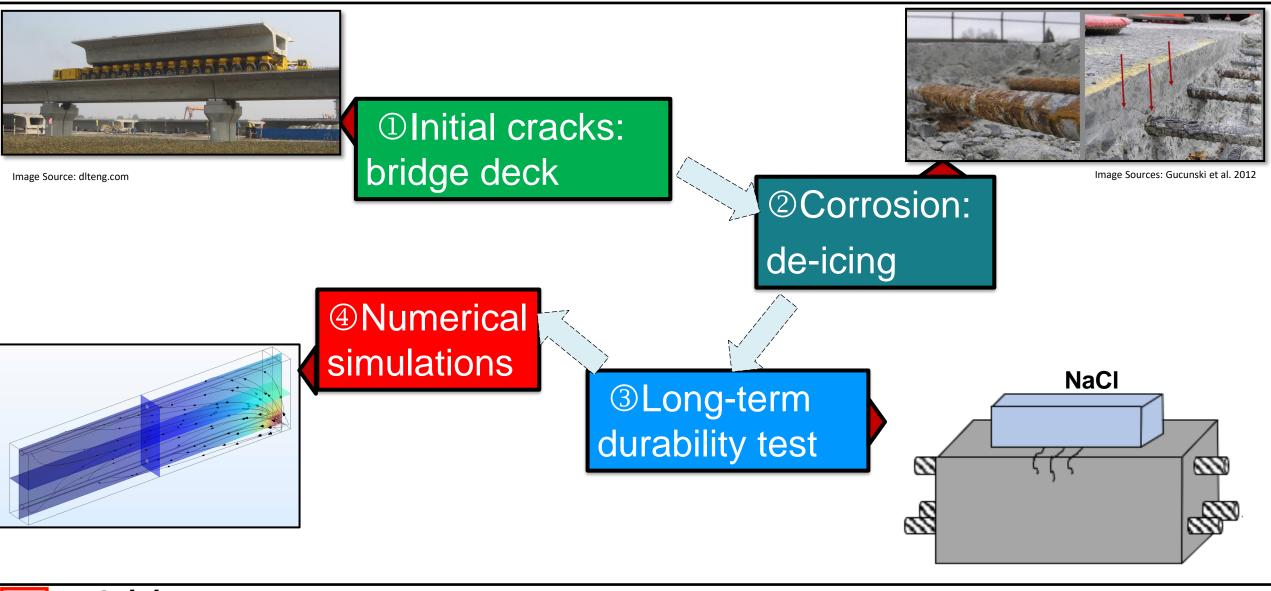Background and motivations

Chloride content

Corrosion current

Summary

DURABILITY ISSUES OF RC

Image Source: dlteng.com

Image Sources: Gucunski et al. 2012

①Initial cracks: bridge deck

②Corrosion: de-icing

④Numerical simulations

③Long-term durability test

NaCl

LAB SPECIMEN TESTING

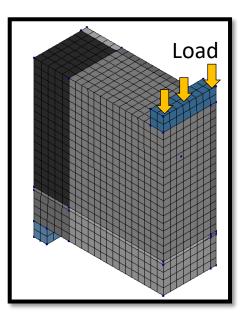- Cracking conditions
  - 0.15 – 0.30 mm
- Five salt brines used
  - 1.5, 3.0, 4.5. 6.0, and 9.0% NaCl
- Wet/Dry cycle to 336 days
  - Each cycle 14 days
- **Limitations:**
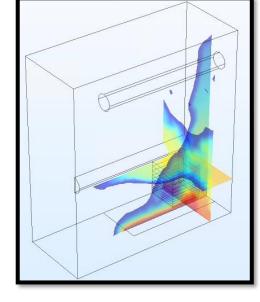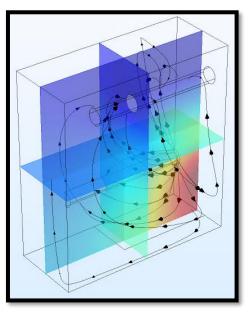 - Crack width *uncontrolled*
  - Time consuming for all the combinations

NUMERICAL APPROACH

- **Numerical method:**
  - ❖ Apply mechanical load
  - ❖ Study chloride distribution
  - ❖ Investigate corrosion current

Mechanical Loading

Cl distribution

Corrosion current

OUTLINE

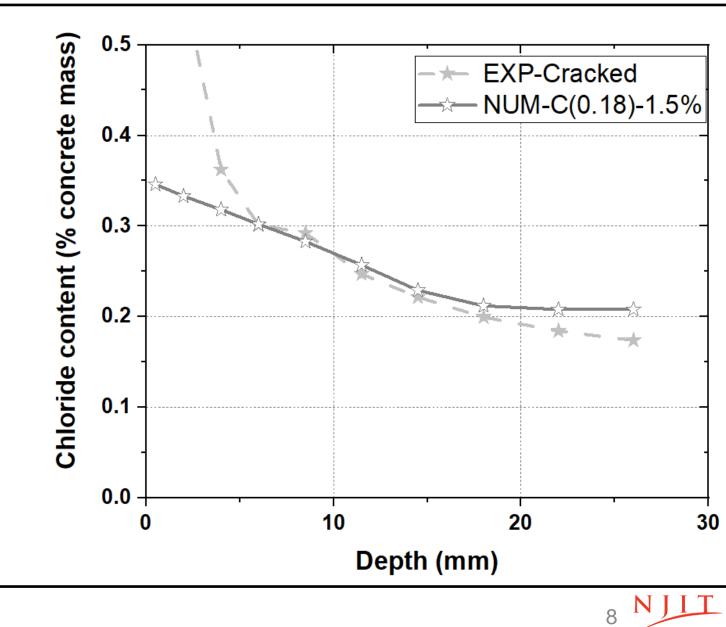Background and motivations

Chloride content
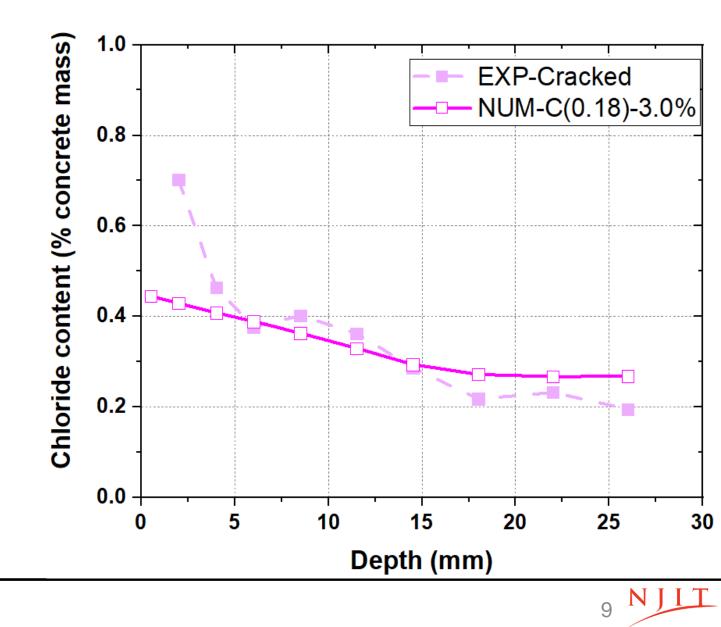
Corrosion current

Summary

CHLORIDE CONTENT-1.5%

- Crack width 0.18 mm
- Conservative close to
  rebar surface

CHLORIDE CONTENT-3.0%
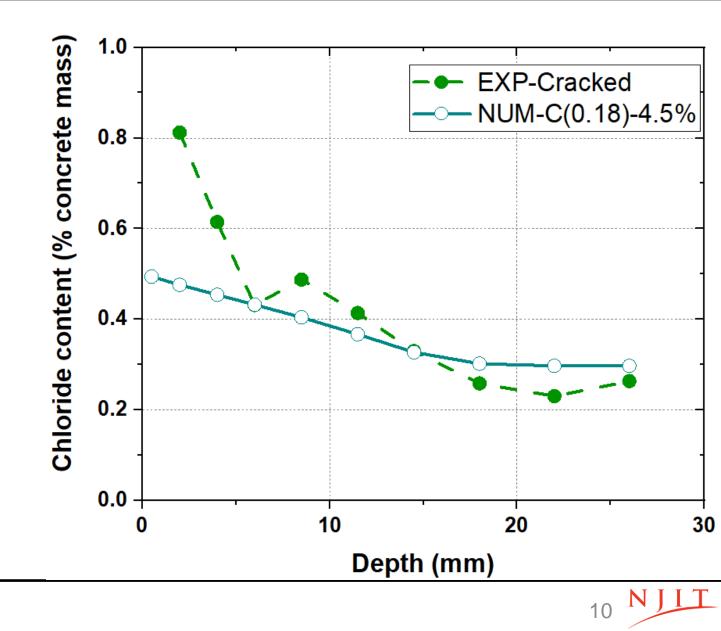
- Crack width 0.18 mm
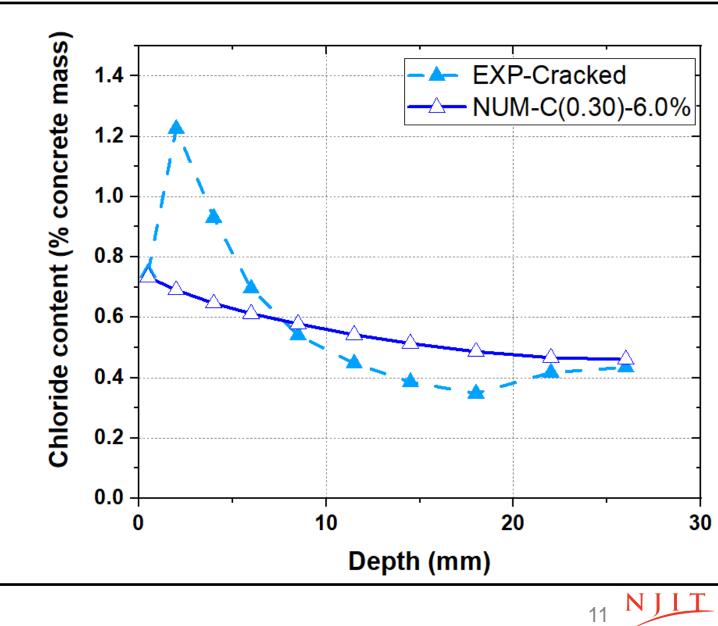- Brine concentration 3.0%

CHLORIDE CONTENT-4.5%

- Crack width 0.18 mm
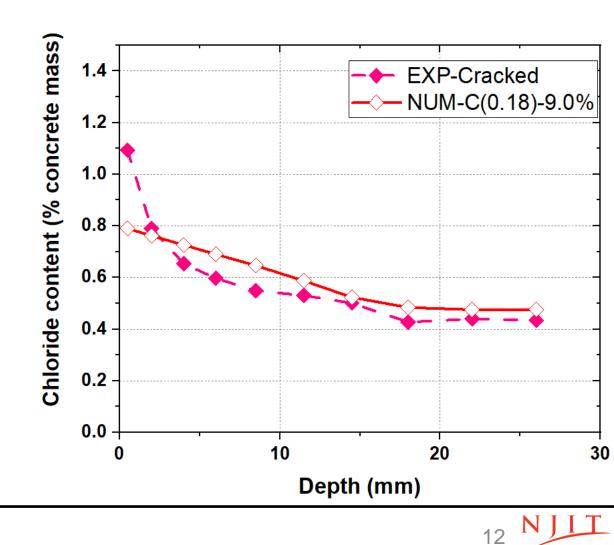- Brine concentration 4.5%

CHLORIDE CONTENT-6.0%

- Crack width 0.30 mm
- Brine concentration 6.0%

CHLORIDE CONTENT-9.0%

- Crack width 0.18 mm
- Brine concentration 9.0%

- Accurate close to steel surface
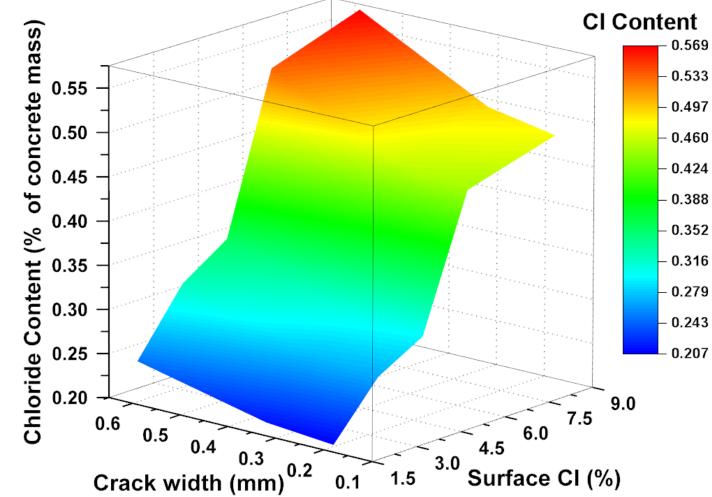- Effective in predicting chloride
- Wet/Dry cycles

- **Crack width less impact**
  - Low surface Cl concentration
- **NaCl % more influential**
  - At 4.5% and 6.0%

OUTLINE

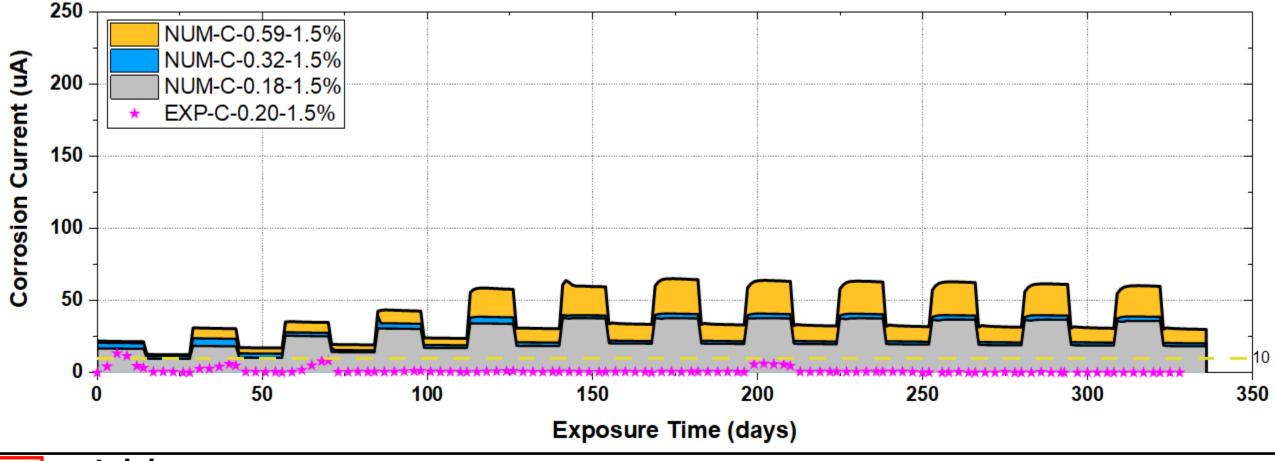Background and motivations

Chloride content
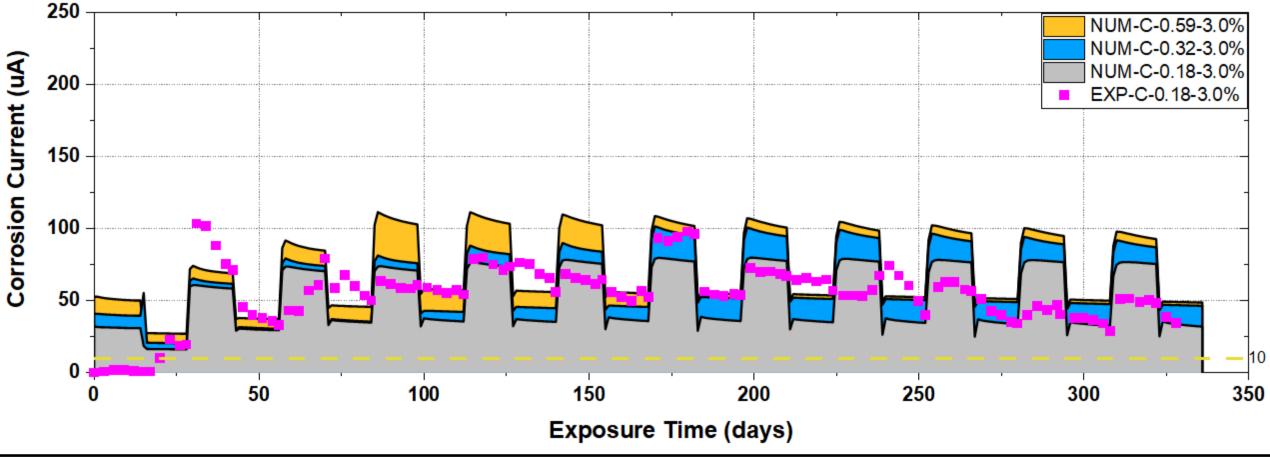
Corrosion current

Summary

CORROSION CURRENT-1.5%

- Increase fast within **200 days**, then stabilized
- Critical crack width 0.30-0.60 mm at 1.5% NaCl

CORROSION CURRENT-3.0%

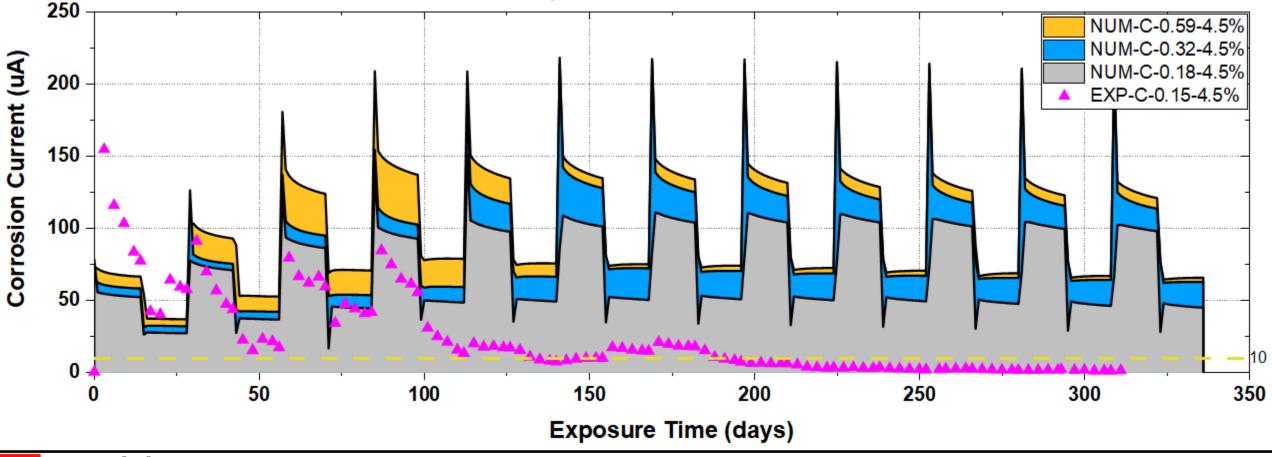- Increase fast within **180 days**, then stabilized
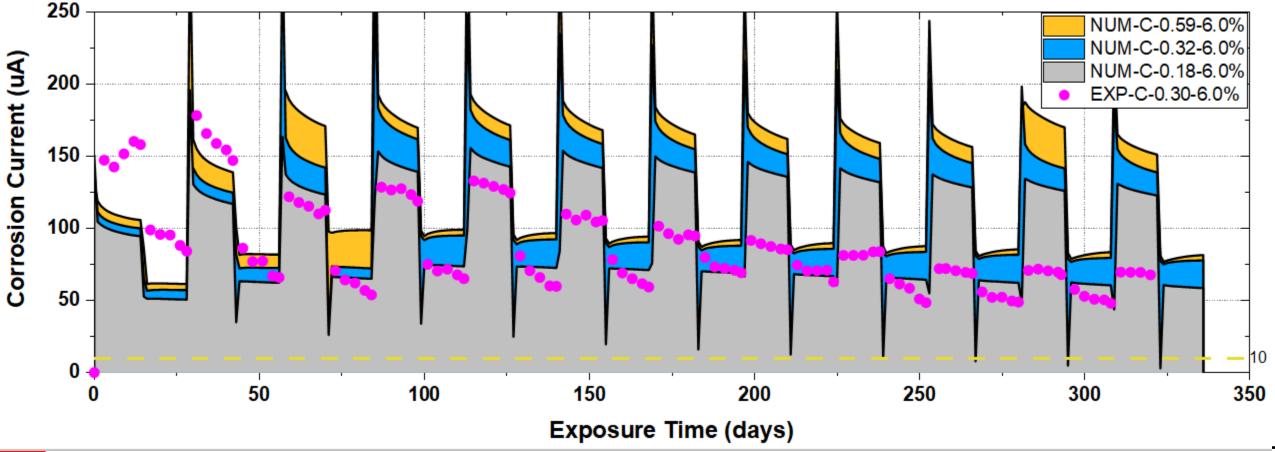- Critical crack width <0.30 mm at 3.0% NaCl

CORROSION CURRENT-4.5%

- Corrosion current increases with bigger cracks
- Increase fast within **150 days**, then stabilized
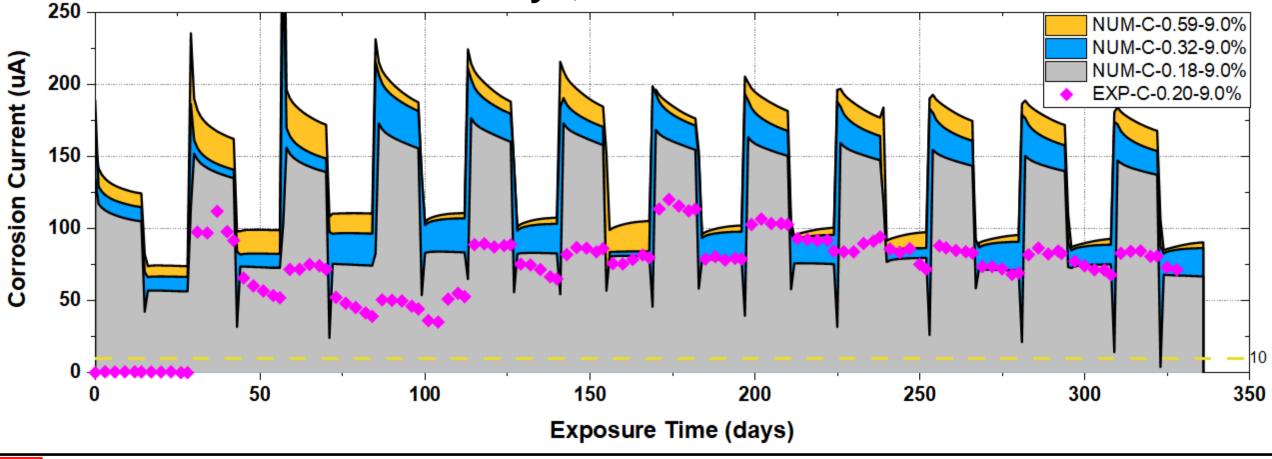
CORROSION CURRENT-6.0%

- Corrosion current increases with bigger cracks
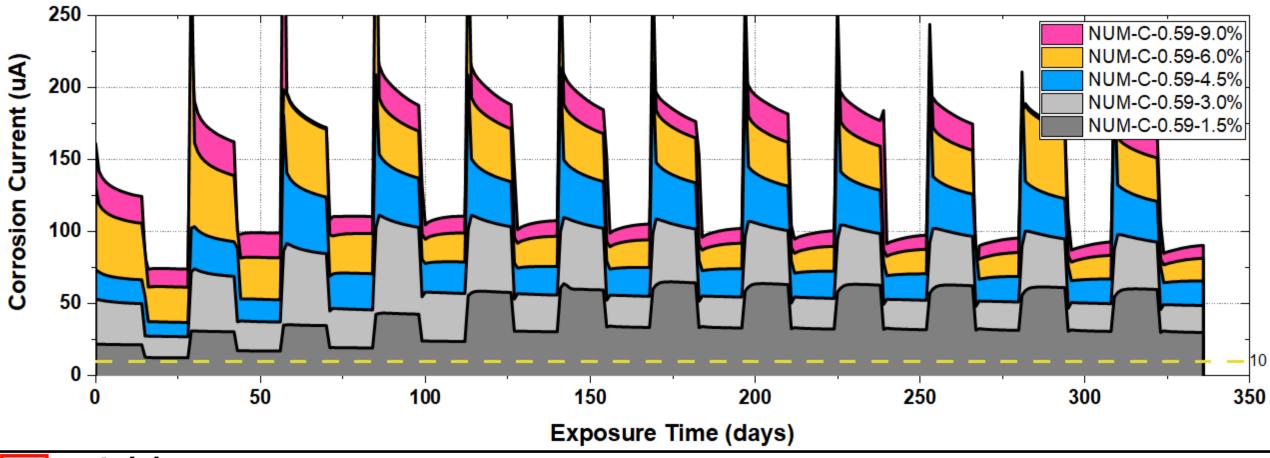- Increase fast within **100 days**, then stabilized

CORROSION CURRENT-9.0%

- ▪ The impact of crack width is **limited**
- ▪ Increase fast within **80 days**, then stabilized

IMPACT OF SURFACE CL

- The impact of Cl % is limited, especially at high concentrations

DISCUSSIONS & TAKE AWAY

- Corrosion status **stabilized faster** in beams with bigger cracks

- Corrosion status **stabilized faster** in beams with higher surface NaCl concentrations

- **Initial cracking** is a key impact factor

- Crack width has **limited impact** on corrosion propagation when crack width is big enough

- The **impact of Cl % is limited** at high concentrations

SUMMARY

- **Numerical approach** is effective in **quantify** the corrosion performance of reinforced concrete beams

- Numerical study confirmed the impact of crack width & chloride concentration

- Corrosion status **stabilized after certain exposure time**

- **Numerical study** revealed that the impact of chloride concentration & crack width is limited in certain conditions

THANK YOU!
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Picture source: