



Numerical Modeling of Reinforcement Corrosion in Cracked Concrete

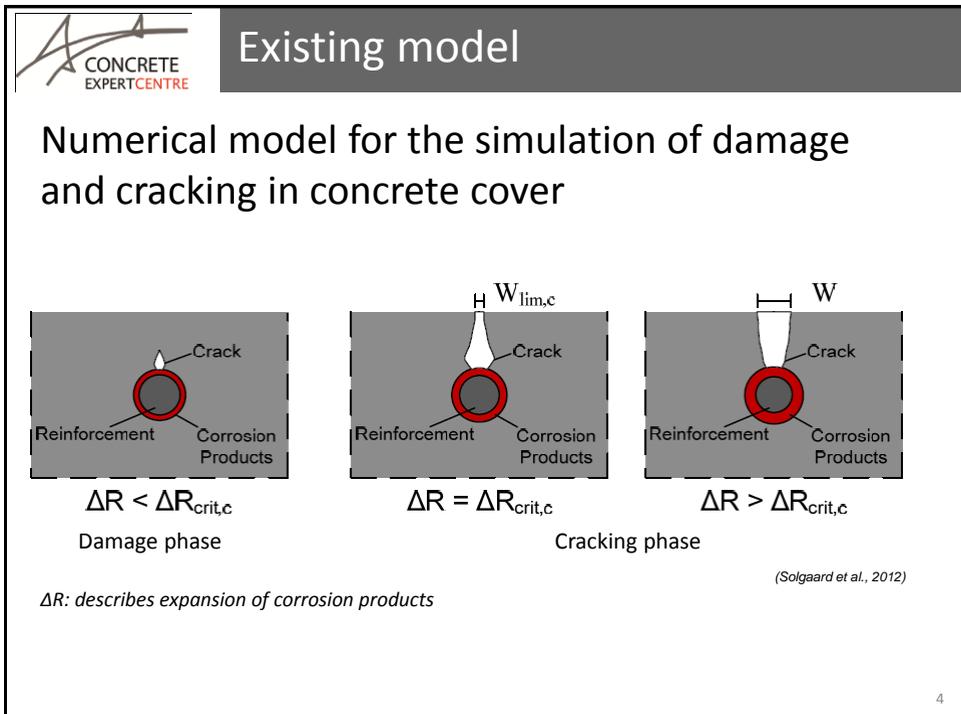
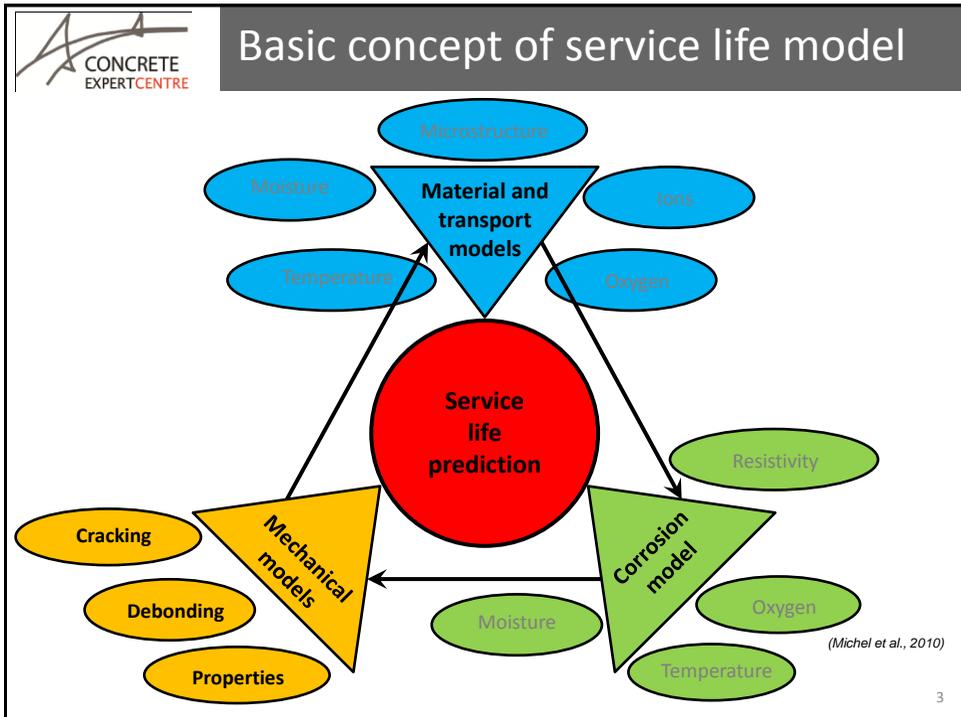
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Prepared for:
Concrete Expert Centre Reference Group Meeting, March 28, 2012



Outline

- Basic concept of service life model
- Existing model
 - Modeling of crack formation
 - Modeling of corrosion
 - Time aspects
- Non-uniform corrosion
 - X-ray attenuation investigations
 - Digital image correlation technique
 - Modeling of corrosion shape
- Future work



Existing model - Modeling of crack formation

CONCRETE EXPERTCENTRE

- Damage and crack formation in the concrete cover
- Debonding of the concrete/steel interface

(Solgaard et al., 2012)

Softening curve of concrete

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Existing model - Modeling of corrosion

CONCRETE EXPERTCENTRE

- Transformation from steel to corrosion products

(Solgaard et al., 2012)

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Existing model – Time aspects

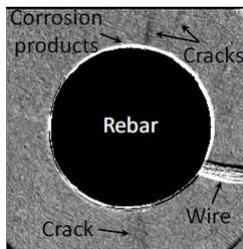
- Time to reach cracking limit state, based on Faraday's

AR limits [μm]	C [mm]	D [mm]	Required time [Years]					
			Low	Moderate	Intermediate	High	Very high	
			$i_{cor}=1.72$ [mA/m ²]	$i_{cor}=4.29$ [mA/m ²]	$i_{cor}=8.58$ [mA/m ²]	$i_{cor}=42.9$ [mA/m ²]	$i_{cor}=85.8$ [mA/m ²]	
PC	38	60	20	19	7.6	3.8	0.8	0.4
	74	30	5	37	15	7.4	1.5	0.7
FRC	42	60	20	21	8.4	4.2	0.8	0.4
	105	60	5	53	21	11	2.1	1.1

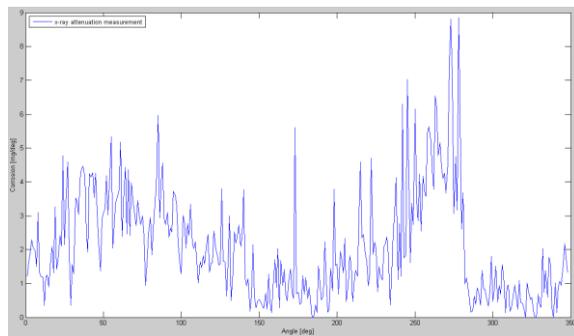
(Solgaard et al., 2012)

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Non-uniform corrosion - X-ray attenuation investigations technique

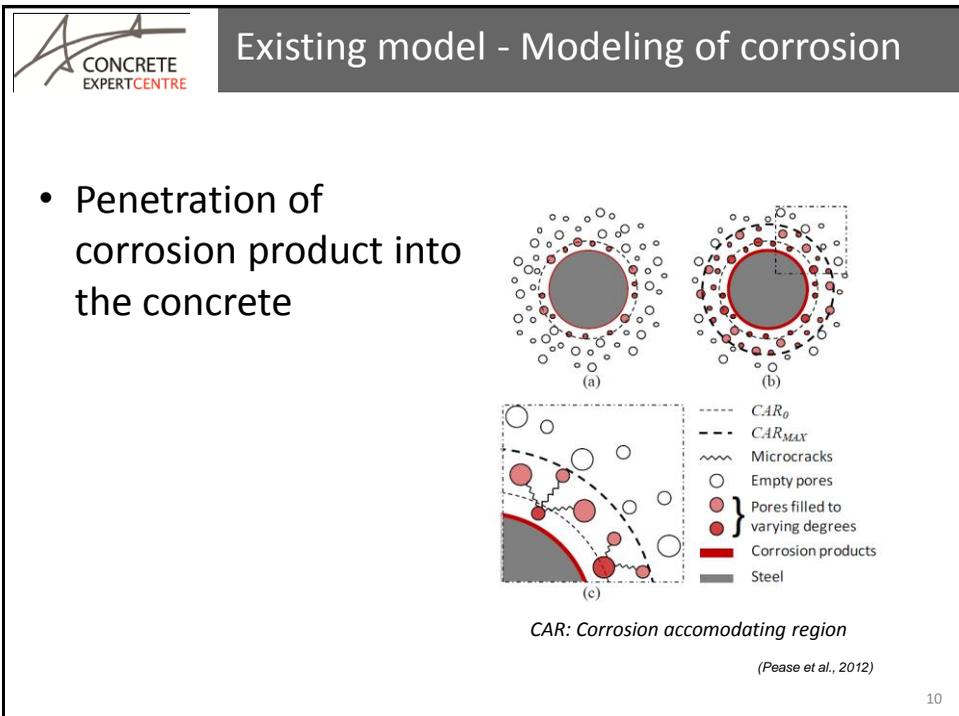
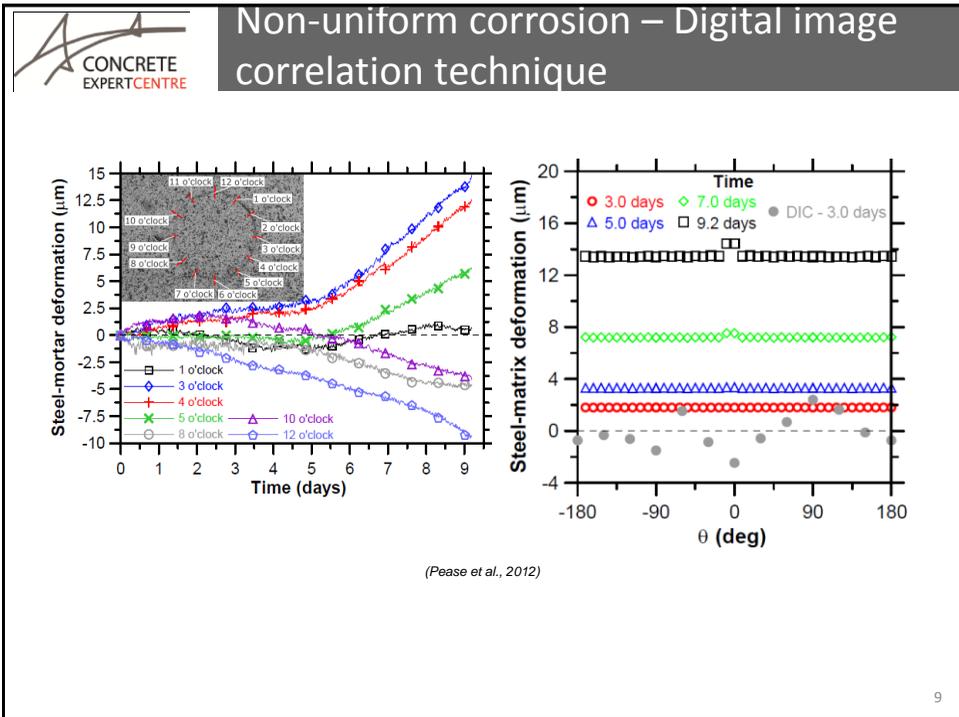


(Pease et al., 2012)



Distribution of corrosion around reinforcement

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Existing model - Modeling of corrosion

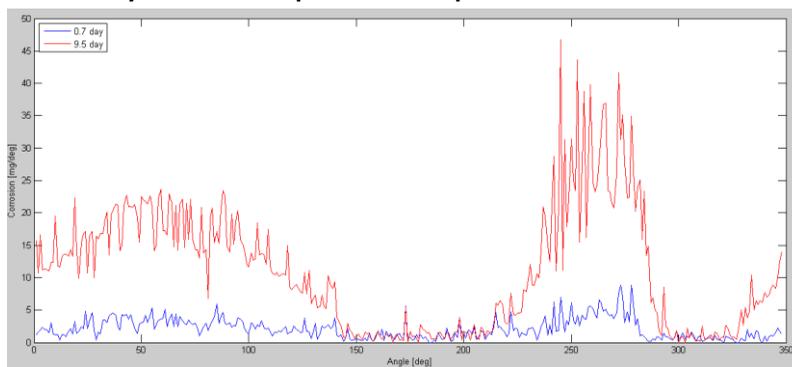
- Elastic properties of reinforcement corrosion products
- **Shape of corrosion**

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Non-uniform corrosion – Modeling of corrosion shape

- At every time step the shape is the same



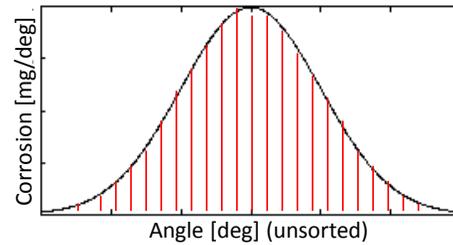
→ shape is normal distributed

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Non-uniform corrosion – Modeling of corrosion shape

- The data is arranged as a normal distribution
- Standard form



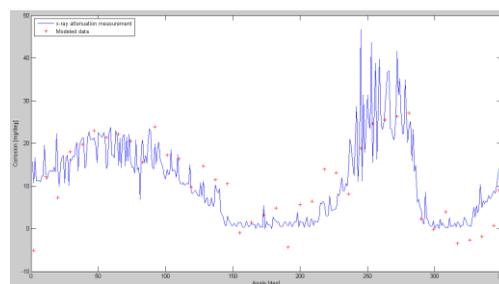
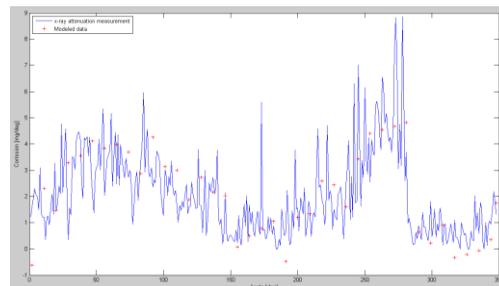
- Input: Mean and standard deviation
- Output: Placement of values around reinforcement

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Non-uniform corrosion – Modeling of corrosion shape

- Modeled data and experimental data from the same time step
- Modeled data and experimental data from different time steps



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Future work

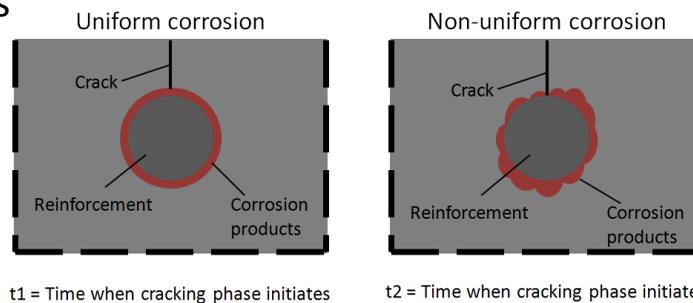
- Non-uniform corrosion related to crack formation
- Modeling of cracks along reinforcement

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Future work - Non-uniform corrosion related to crack formation

- Implementation of non-uniform corrosion in existing model
- Probabilistic influence on the formation on cracks



- How is t_1 and t_2 related? $t_1 > t_2$, $t_2 > t_1$, $t_1 \approx t_2$?

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Future work - Modeling of cracks along reinforcement

- Information of anodes length along the reinforcement
- Predicted corrosion rates for the various anodes