





Quantifying the Value of Structural Health Monitoring

Concrete Bridge

Reinforcement Corrosion Sensor Alternatives

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- Context / Approach
- Corrosion sensor

2. Decision scenario

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- 5. Value of the SHM information for the owner/concessionaire







1. Early Research Program ERP_SI_BRIDGE : Scope & focus

- Advanced assessment of existing RC structures
- Accounting for multiple sources of uncertainty, i.e.:
 - randomness in intrinsic material properties,
 - randomness in defects due to load history,
 - (FEM) modelling uncertainty,
 - randomness in defects due to deterioration mechanisms : CORROSION









1. Early Research Program ERP_SI_BRIDGE : Assessment & prediction







1. Early Research Program ERP_SI_BRIDGE : MSDF

MSDF: reliable corrosion detection

- measuring system is based on multiple sensors and interpretation model
- additional data come from intake testing and sampling
- physical and the statistical model captures the relations between the measurable corrosion-relevant parameters











1. Early Research Program ERP_SI_BRIDGE : MSDF

MSDF: reliable corrosion detection

- Data, physics and Expert Opinions captured in Bayesian Net
- Autonomous interpretation model

→ Likelihood of Corrosion based on indicators

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Which SHM technique should the owner apply which results in the minimization of the remaining service life cost?

Answer depends on:

the **cost** related to each of the measuring techniques; the **accuracies** of each of the measuring techniques; the possible **actions** resulting from the outcomes of the measuring techniques;

the **actual state** of the structure; the **cost and benefits** related to the failure or existence of the structure.





SHM (MSDF) : Vol Categorization & Flowchart



Sensor Alternatives

(1) Half-cell potential measurements

Probability of active corrosion. Sensitive to environmental influences. Interpretation by means of American Standard ASTM C876.

(2) MSDF

Probability of active corrosion. Embedded sensors

Environmental data

Multiple Electrochemical data

Knowledge based (expert) system for data interpretation.

Autonomous interpretation.







Case study

Fictitious, reinforced concrete slab bridge located in Rotterdam.



Results from file-survey (nominal / characteristic values): The design lifetime: 50 years; Concrete cover: 30 mm; Curing time: 28 days Water cement ratio: 0.5 [-]; Cement type: CEMI; Rebar diameter: 12 mm Tensile splitting str.: 2.2 Mpa; Environmental class: XS3; Average relative humidity: 80%; Average temperature: 20 °C





Case study

Assumptions

Both measuring techniques equally expensive while compiling first models. MSDF better information than half-cell potential measurements.

MSDF

Epot + ASTM C876

P(depass)	depass	no depass
0-10 %	0.05	0.9
10-90%	0.05	0.05
90-100%	0.9	0.05

P(depass)	depass	no depass
0-10 %	0.2	0.6
10-90%	0.2	0.2
90-100%	0.6	0.2



3. Methods applied



3. Methods applied

Ongoing:

- Hierarchical prior model for depassivation to be added
- Developments w.r.t. MSDF sensor to be taken into account
- Costs to be quantified
- Time as parameter in model to be included
- Other actions to be included
- Spatial variability









4. Results (to be) obtained

		Description					
	Туре	Concrete bridge					
Structure	Life cycle phase	operation					
	Performance	deterioration					
	Decision maker	municipality as bridge owner					
Decision scenario	Decision point in time	operational					
	Objective	Minimize total maintenance costs					
	Actions	maintenance: cathodic protection, coating or cover renewal					
Decision variables	Action parameters	type of action					
	Information acquirement strategies	MSDF sensor; potential sensor					
	Strategy parameters	tpe of sensor					
	Value of Information	## Euro					
Results	Decision rules	Type of sensor in combination with maintenance policy					

5. Value of the SHM information for the owner/concessionaire

Owner Minimized total maintenance costs

Optimal SHM method

Optimal Maintenance policy

Maintenance policy is adaptive/dynamic

Sensor

Insight in sensor Vol

Business case for sensor

Innovation development incentives







Thank you for your attention

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