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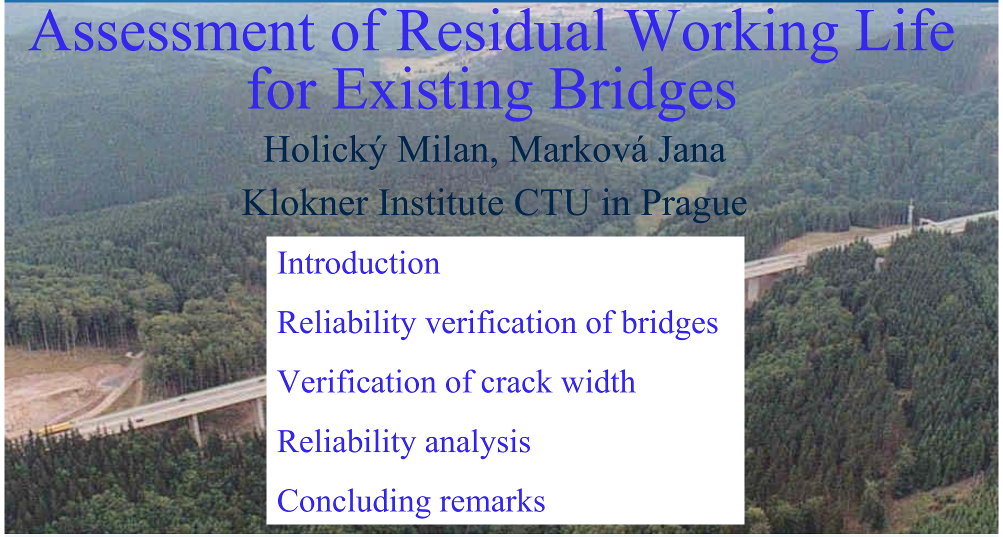

Assessment of Residual Working Life for Existing Bridges

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- Introduction
- Reliability verification of bridges
- Verification of crack width
- Reliability analysis
- Concluding remarks

CENTRAL EUROPE TOWARDS SUSTAINABLE BUILDING 2010 CESB 10 PRAGUE

Introduction

Extended exploitation of existing structures including bridges

– provide social, economical and also cultural advantages

– help to preserve values of historical character

Prescriptive documents

ČSN EN 1990 Basis of design

ČSN ISO 13822 Assessment of existing structures

TP 224 Verification of existing road concrete bridges

Different criteria for existing and new stuctures

Criteria	Existing structures	New structures
Economical	incremental cost of increasing the structural safety is commonly high	incremental cost of increasing the structural safety is commonly lower
Social	may be significant due to reduction or disruption of serviceability and preservation of heritage values	commonly less significant than for existing structures
Sustainability	in large measure existing materials are used, leading to reduction of waste and recycling	commonly new materials are applied

Classification of design criteria

Remaining working life (in years)	Post-tensioned bridges with tendons bonded	non-bonded	Reinforced bridges
50	0,2 mm	0,2 mm	0,3 mm
25	0,2 mm	0,3 mm	0,4 mm
10	0,3 mm	0,4 mm	0,5 mm

Verification of crack width

Serviceability condition $w_k(\boldsymbol{x}_k) \le w_{lim}$

$$w_k = s_{r,max}\,(\varepsilon_{sm} - \varepsilon_{cm}) = 1{,}7\, s_{r,m}\,(\varepsilon_{sm} - \varepsilon_{cm})$$

$$s_{r,m} = kc + 0{,}25 k_1 k_2 d/\rho_{p,eff}$$

$$\varepsilon_{sm} - \varepsilon_{cm} = \frac{\sigma_s - (1+\alpha_e \rho_{p,eff})\,k_t \dfrac{f_{ct,eff}}{\rho_{p,eff}}}{E_s}$$

mean crack spacing

mean strain

Probabilistic models

Basic variable	Symbol	Distr.	Mean μ	St. dev. σ
Concrete tensile strength	f_{ct}	LN	3,5	0,7
Modulus of elasticity for steel	E_s	DET	200000	-
Concrete modulus of elasticity	E_c	LN	35000	3500
Creep coefficient	φ	LN	1,46	0,4
Coefficient of bond strength	k_1	LN	0,8	0,21
Coefficient for cover	k	LN	2	0,5
Length of span	L	DET	15	-
Diameter of bar	d	DET	0,028	-
Cross-section height	h	DET	0,9	-
Surfacing thickness	h_1	LN	0,1	0,01
Reinforcement cover	c	BET *	0,04	0,01
Crack width model uncertainty	ξ_w	LN	1,0	0,15μ
Crack width limit uncertainty	ξ_{lim}	LN	1,0	0,1μ
Density of concrete	ρ	N	2500	0,08μ
Tandem system (TS)	Q	GUM	500	58
UDL system	q	GUM	20	0,2

Reliability analysis of bridge

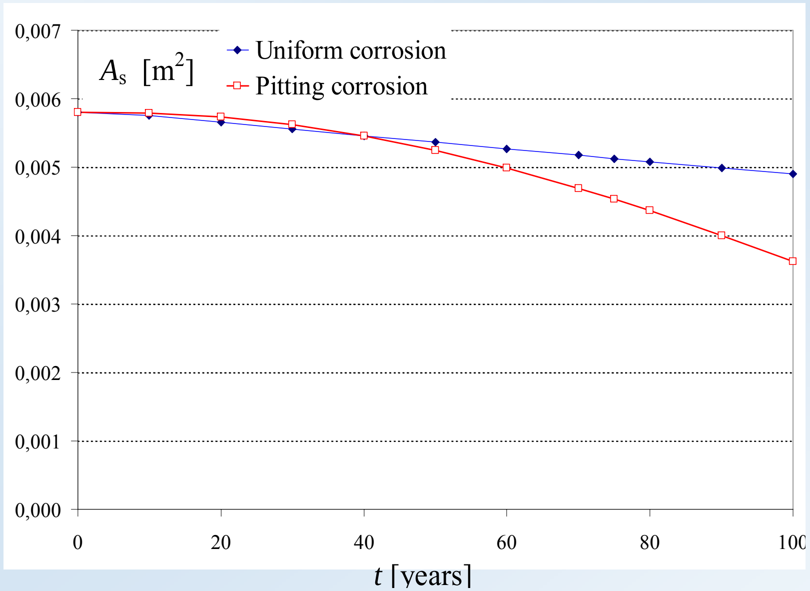
The probability P_F of a random crack width exceeding the crack width limit w_{lim}

$$P_F(\boldsymbol{X}, t) = P\{\xi_{lim}\, w_{lim} - \xi_w\, w(\boldsymbol{X}, t) < 0\}$$

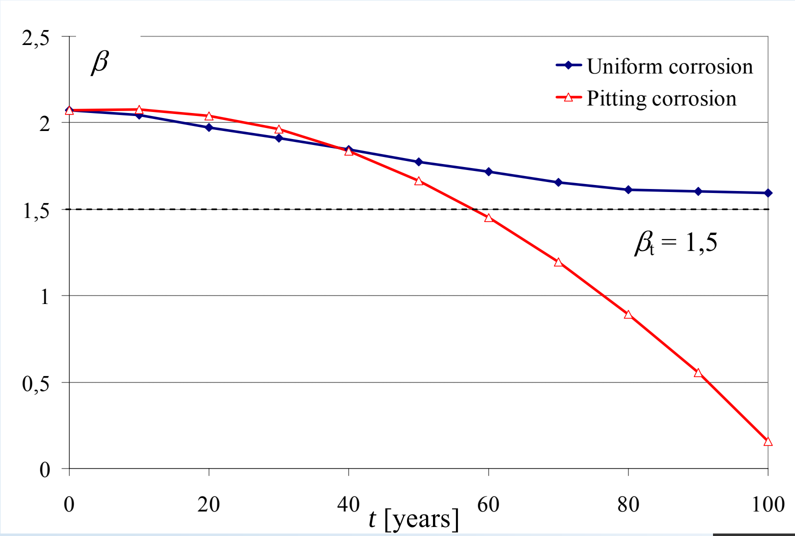
where the following condition should be satisfied

$$P_F(\boldsymbol{X}, t) \le P_t$$

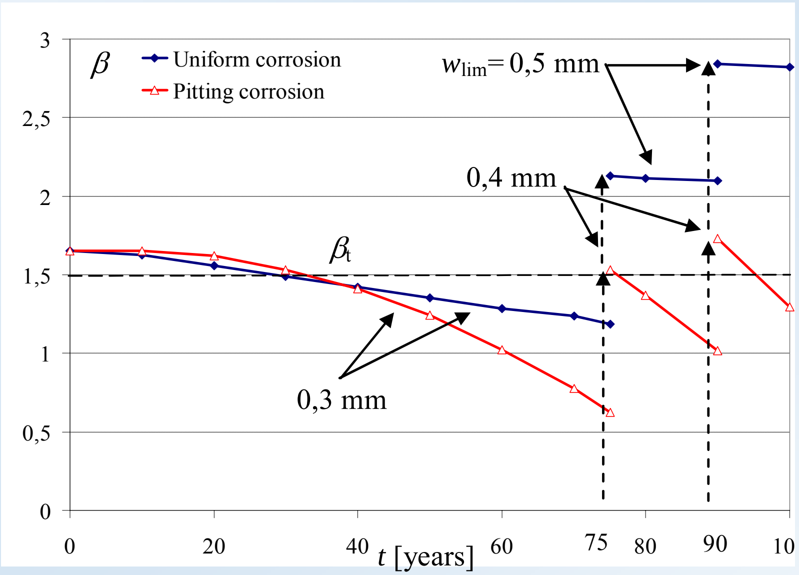
Assessment of existing bridge



Reliability index for uniform and pitting corrosion versus time *t*



Reliability level of a deteriorating bridge for recommended crack width limits



CONCLUDING REMARKS

1. The uniform corrosion leads to a smaller reduction of reinforcement area, and to higher reliability indices than the pitting corrosion.

2. The results of probabilistic analysis of a selected deteriorating bridge indicate that the reliability after about half of the working life (50 years) may be rather low ($\beta < 1,3$).

3. It appears that the type of corrosion (uniform, pitting) and potential consequences of failure should be taken into account in the recommendations for the crack width limits given in the current prescriptive documents.

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