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A/CZ0046/2/0013 ASSESSMENT OF HISTORICAL IMMOVABLES

Reliability Assessment of Existing Bridges

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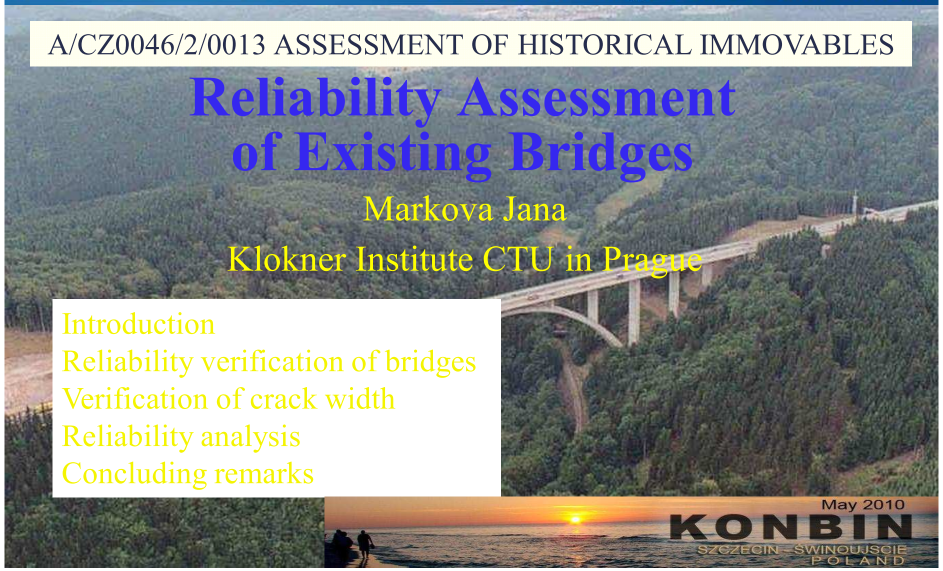


May 2010

KONBIN

SZCZECIN – SWINOUJSCIE POLAND

Partial Factor Method

Characteristic values based on actual properties

Design values

- actions $F_d(\beta, V_f) = \gamma_F(\beta, V_F)\, F_{rep}$
- material properties $f_d(\beta, V_f) = f_k / \gamma_M(\beta, V_f)$
- dimensions $a_d(\beta, V_f) = a_k \pm \Delta a(\beta, V_a)$

Partial factors $\gamma_F(\beta, V_F)$ and $\gamma_M(\beta, V_f)$ depends on β and V.

Introduction

Further exploitation of existing structures including bridges

– provide social and economical 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 Ověřování existujících betonových mostů

Classification of design criteria

Remaining working life (in years)	Pre-tensioned bridges	Post-tensioned bridges with tendons bonded	non-bonded	Reinforced bridges
50	B	C	D	E - 0,3 mm
25	C	D	E	F - 0,4 mm
10	D	E	F	G - 0,5 mm

Verification of crack width

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

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

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

mean crack spacing

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

mean strain

Model Code 2010

$$s_{r,k} = 2\left(kc + \frac{f_{ctk,0,05}}{4\tau_{bk}} \frac{d}{\rho_{p,eff}}\right)$$

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	$0{,}15\mu$
Crack width limit uncertainty	ξ_{lim}	LN	1,0	$0{,}1\mu$
Density of concrete	ρ	N	2500	$0{,}08\mu$
Tandem system (TS)	Q	GUM	500	58
UDL system	q	GUM	20	0,2

Reliability analysis of bridge

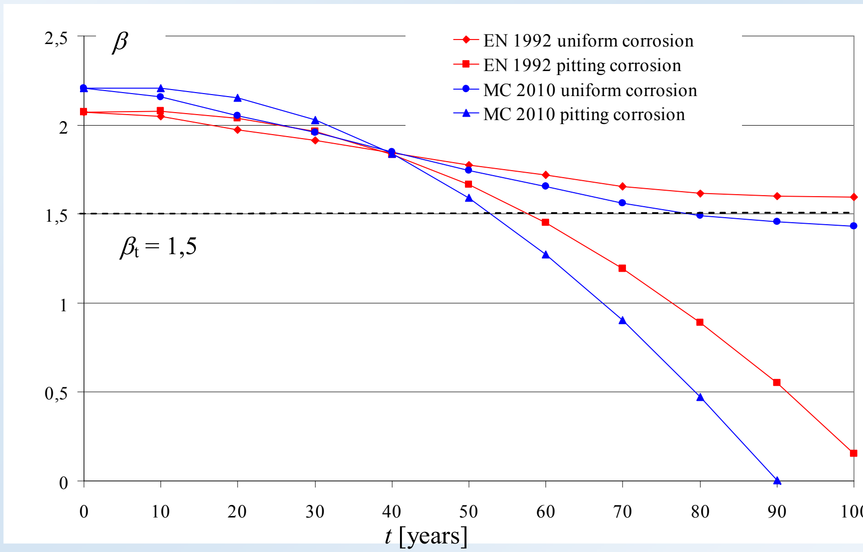
The probability P_F of a random crack width exceeding the crack width limit w_{lim} is determined as

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

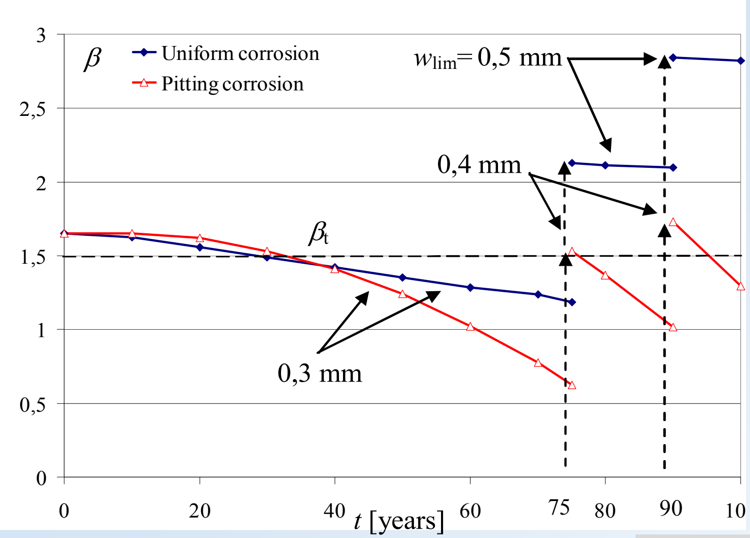
where the following condition should be satisfied

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

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



Reliability level of a deteriorating bridge for recommended crack width limits



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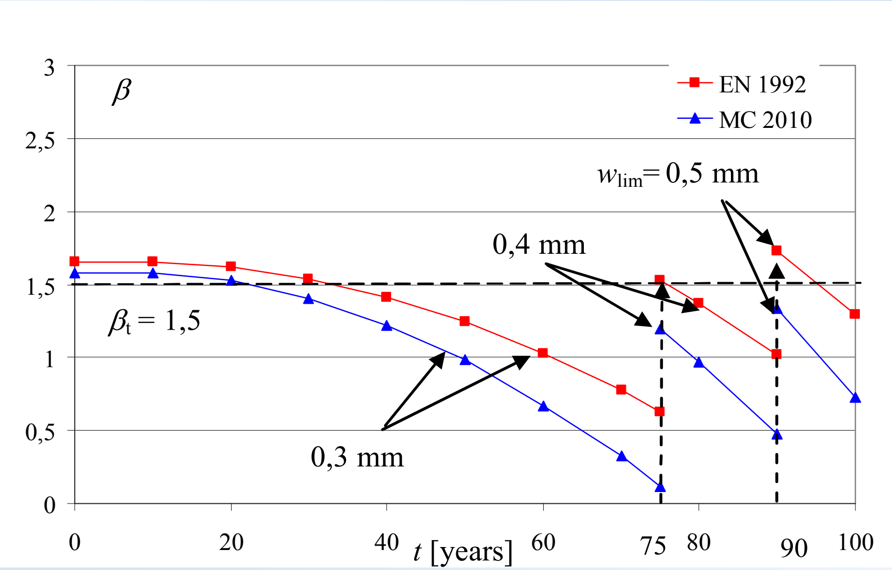
CONCLUDING REMARKS

1. The existing bridges are rapidly deteriorating due to effect of de-icing salts and 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. The crack width models provided in Eurocodes leads to similar but slightly favourable results than MC 2010.
4. 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.

Comparison of crack width models in EN 1992 and MC 2010



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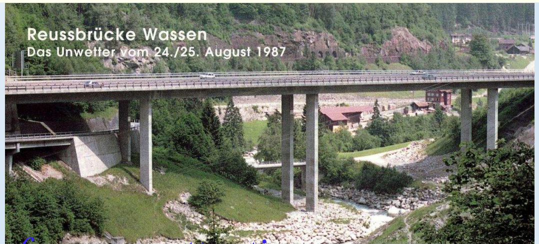

Thank you for your attention