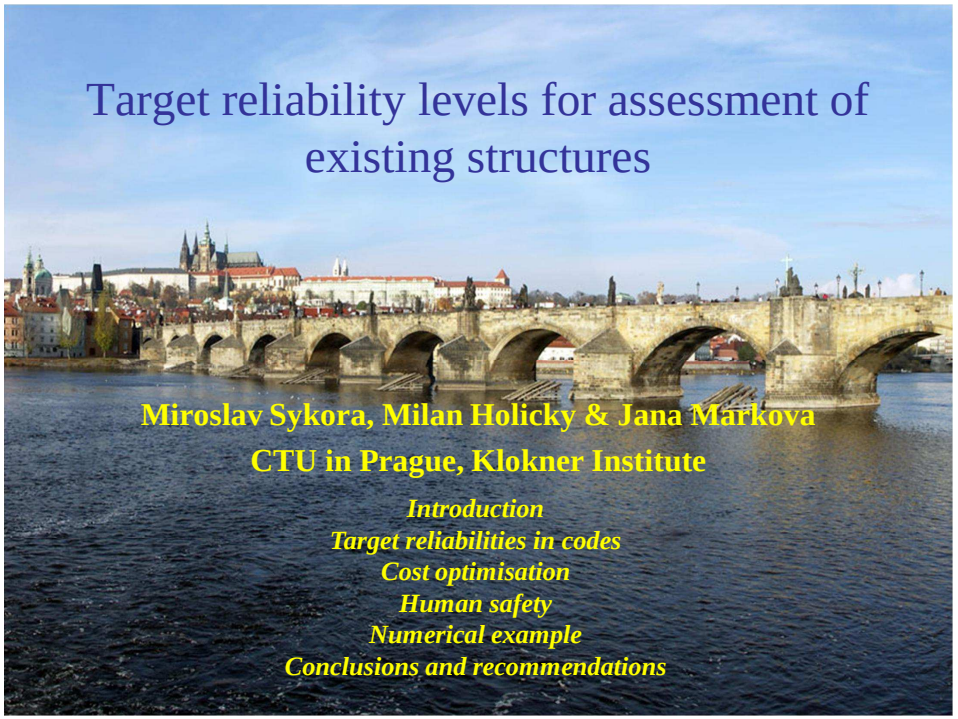


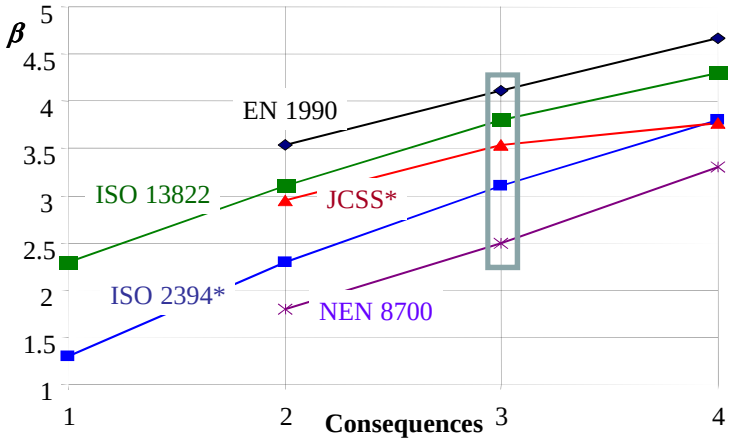
Introduction

- Reliability ***assessment*** of existing structures different from structural design (expensive safety measures, lower working life)
- Target reliability levels needed for the ***probabilistic assessment*** or adjustments of ***partial factors***
- ISO 13822 - possibility to specify the target reliability levels by ***optimisation*** of the total cost related to a remaining working life
- The present contribution:
  - ***overview*** of the target reliabilities in codes
  - application of cost ***optimisation***.

Model structure - existing building with the remaining working life of 15 or 30 years, moderate costs of safety measures and moderate failure consequences

Target reliability indices β

(example - remaining working life t_r = reference period = 15 years, Ultimate Limit State)



EN		low	normal	high
ISO	small	some	moderate	great
JCSS		minor	moderate	large

* normal relative costs of safety measures, moderate rel. costs of safety measures

Cost optimisation at the time of assessment

• Cost of foreseen ***inspections and maintenance*** – assumed to be influenced by decision parameter d insignificantly

• ***Repair cost*** - cost of ***immediate*** (and ***future***) repairs:
- C_0 - costs independent of d,
- C_m – marginal cost per unit of d

• ***Failure cost*** C_f:
- ***direct*** consequences - cost of repair or replacement
- ***indirect*** consequences (economic, societal, environmental)

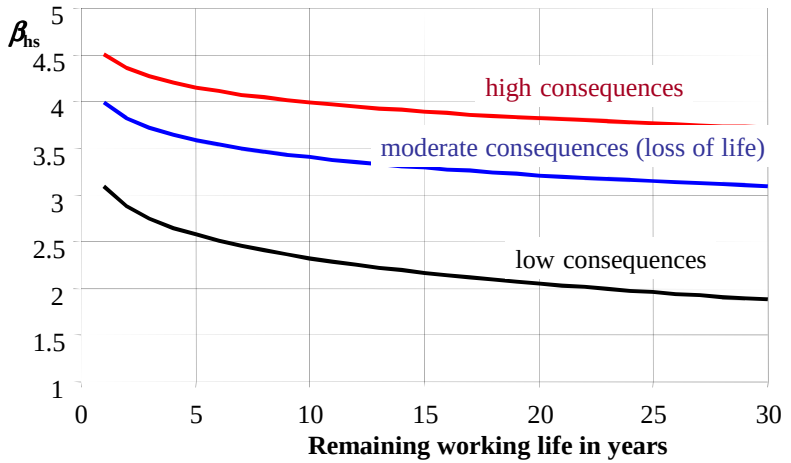
$$E[C_{tot}(t_r,d)] = C_0 + C_m \times d + E[C_f(t_r,d)]$$

Optimisation from the perspective of an owner of the structure

Requirements on human safety

• Steenbergen & Vrouwenvelder (2010) - maximum ***probability*** to ***become*** a ***victim*** of structural failure 10^{-5} per year

• Present study: ***10^{-6} per year*** according to ISO 2394 (1998)



An example of a generic member

• Resistance ratio d_0 of the design resistance ***before*** the repair over the resistance required by Eurocodes for new structures

• Resistance ratio d of the design resistance ***after*** the repair over the resistance required by Eurocodes (decision parameter)

• Probabilistic assessment

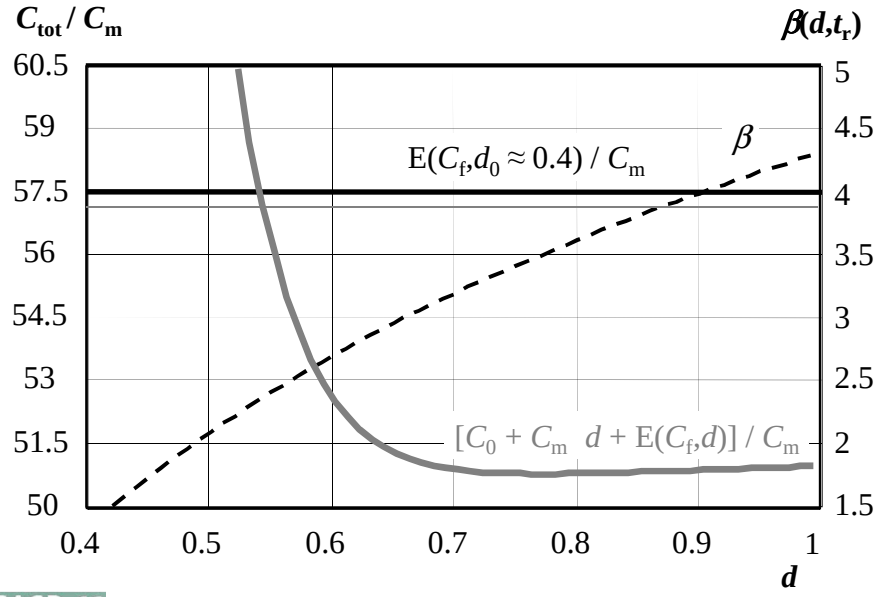
$$Z(\mathbf{X},t) = K_R R(d) - K_E [G + Q(t)]$$

Variable	Sym.	Dist.	m_X / x_k	V_X
Resistance	R	LN	1.3	0.15
Permanent load	G	N	1	0.05
Imposed load (50 years)*	Q_{50}	GU	0.6	0.35
Resistance uncertainties	K_R	LN	1.2	0.15
Load effect uncertainties	K_E	LN	1	0.1

*modified with respect to t_r

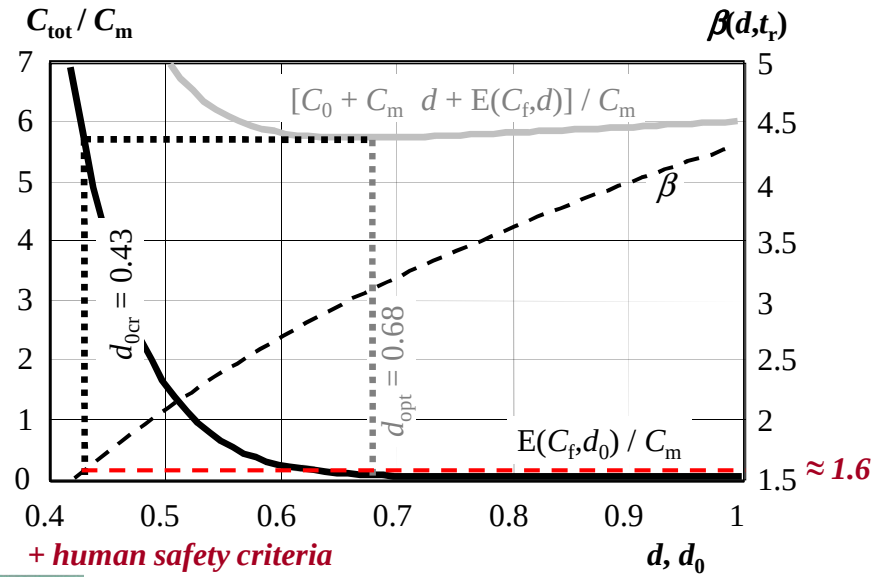
Decision on repair

(t_r = 15 years, C_f / C_0 = 20, C_f / C_m = 1000, discount rate 0.03)



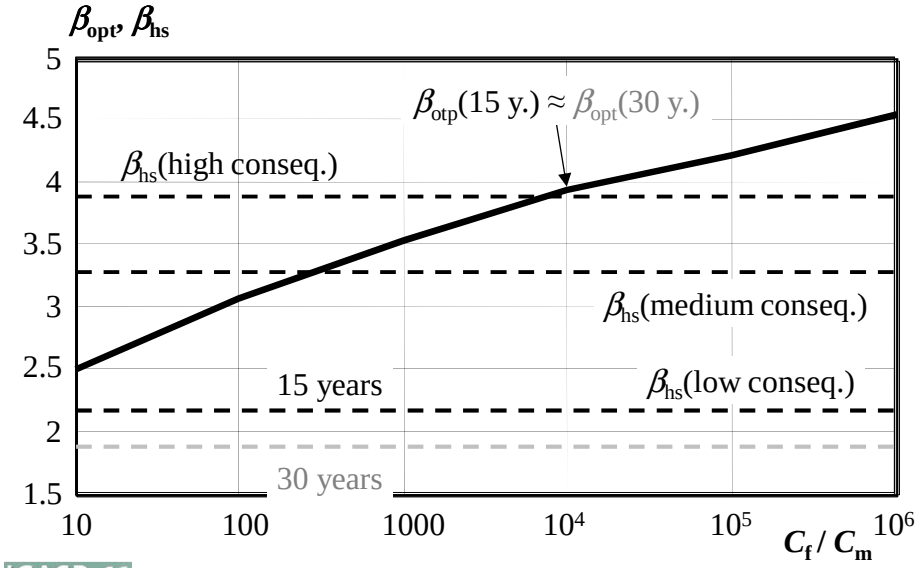
Reliability level below which structure is repaired

(t_r = 15 years, C_f / C_0 = 20, C_f / C_m = 100)



Optimum repair strategy

(t_r = 15 years, independent of C_f / C_0)



Overview of target reliabilities for the model structure

Code, method	Remaining working life	
	15 years	30 years
EN 1990	4.1	4.0
ISO 13822	3.8	3.8
ISO 2394	3.1	3.1
NEN 8700	2.5	2.5
Allen (1993)	3.0	3.0
Optimisation - minimum acceptable β	3.3	3.1
Optimisation - optimum repair	3.5	3.5

Conclusions of the study

- It is ***uneconomical*** to require the same target reliabilities for existing structures as for new structures.
- ***Two target levels*** are distinguished – the minimum level below which a structure should be repaired and optimum level for repair.
- ***Direct*** and ***indirect*** failure ***consequences*** should be taken into account in the optimisation.
- Minimum levels for ***human safety*** should be respected.
- The target reliability levels are primarily dependent on the ***failure consequences*** and ***marginal cost*** per unit of a decision parameter.
- Repair costs independent of the decision parameter, remaining working life and discount ratio are ***less significant***.

Thank you for your attention

In some cases optimization is very difficult