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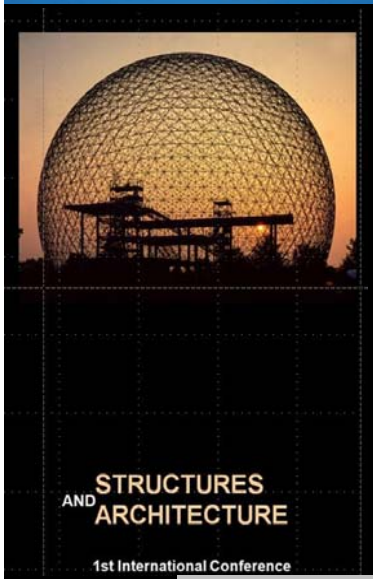

Reliability assessment of industrial heritage structures and application to a light-weight steel roof

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Introduction

• ***Industrial heritage*** - structures of significant architectural, historic or technological value

• Part of urban ***landscape***, visual ***historical landmarks***

• 10 000 buildings and bridges in the Czech Republic

• Insufficient attention to recognizing, declaring and protecting - ***gradual extinction***

• Re-use and adaptation – integration into an urban lifestyle, protection of cities' heritage

• The ***contribution*** is aimed to:
- promote ***discussion*** between civil engineers and architects on the industrial heritage
- indicate its ***architectural*** and cultural ***significance***
- provide framework for complex ***reliability assessment***

Importance of protection

• Protection – ***multidisciplinary topic*** (architectonic, civil engineering, historical and ecological aspects)

• Adaptations and re-use contribute to the sustainable development:
- preservation of the ***cultural values***
- ***recycling*** of resources and avoiding wasting energy
- facilitating the ***economic regeneration***.

• Importance increasing due to shortage of energy, economic crisis and environmental protection.

• Initiatives:
- International Committee on the Conservation of the Industrial Heritage ***TICCIH***
- Research Centre for Industrial Heritage (CTU in Prague)
- research project Assessment of historical immovables

General aspects of the reliability assessment

• Minimisation of construction interventions (respect of the original conception, durability), but sufficient ***reliability***

• Social and cultural aspects - loss of ***cultural*** and heritage ***values***

• Economic aspects - additional ***costs to increase reliability***

• Sustainable development - ***recycling*** of materials

• Deterministic design procedures conservative (expensive repairs, losses of cultural and heritage value)

• Probabilistic procedures improving the reliability assessment by:
- better description of ***uncertainties***
- facilitating inclusion of the ***results of inspections*** and ***testing*** and satisfactory pas performance

Probabilistic assessment

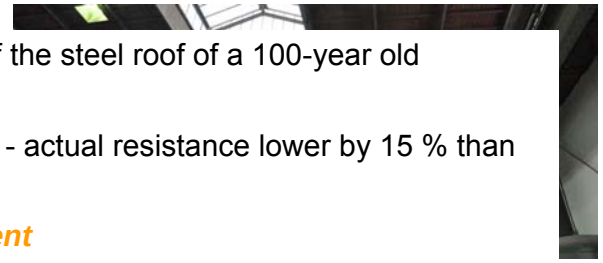
$$p_f(t_D) = P\{Z[X(t_D)] < 0\} \le p_t, \quad \beta = -\Phi^{-1}[p_f(t_D)] \ge \beta_t$$

- Resistance - decreasing function, loads – stochastic processes

- ***New information*** related to structural conditions:
  - inspections, measurements (deterioration, materials, geometry)
  - satisfactory past performance

- ***Target reliability***:
  - ISO 2394 - moderate failure consequences, moderate costs of safety measures - $\beta_t = 3.1$
  - empirical models $\beta_t \approx 2.7$ - 3.4
  - minimisation of the total working-life cost (inspections, maintenance, repairs, failure consequences)

Numerical example



- Reliability assessment of the steel roof of a 100-year old industrial heritage building

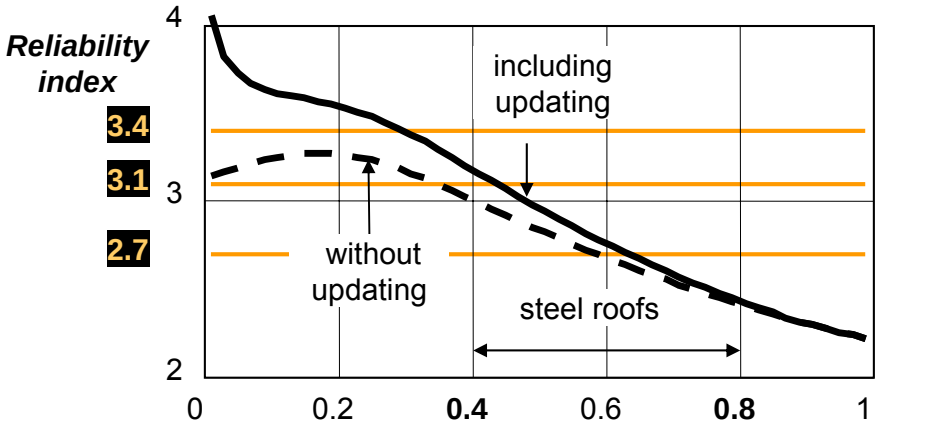
- Deterministic verification - actual resistance lower by 15 % than required by Eurocodes

- ***Probabilistic assessment***

Variable	Sym.	Dist.	μ_X / x_k	V_X
Resistance	R	LN	1.19	0.08
Perm. load	G	N	1	0.05
Snow load (50 years)	S_{50}	GU	1.11	0.27
Wind action (1 year)	W_{APT}	GU	0.3	0.5
Resistance uncertainties	K_R	LN	1.15	0.05
Load effect uncertainties	K_E	LN	1	0.1

Reliability analysis

- Limit state function: $Z(t) = K_R R - K_E (G + S_{50} + W_{APT})$



Conclusions

- ***Protection*** of the industrial heritage contributes to the sustainable development.

- Insufficient attention to recognizing and protecting the industrial heritage may lead to its ***extinction***.

- Desired protection requires a ***public recognition*** of the industrial heritage to be equally important as any other cultural heritage.

- ***Educational programs*** and relevant ***legislation*** are needed.

Conclusions

• Significant ***uncertainties*** related to actual structural conditions can hardly be described by simplified design procedures.

• Probabilistic methods allow to better consider uncertainties, results of inspections and tests and satisfactory past performance.

• The ***target reliability*** might be lower than 3.8 recommended in Eurocodes; it may vary from 2.7 to 3.4 for ***moderate consequences***.

• Consideration of the satisfactory past performance may improve the reliability estimates particularly for structures exposed to dominant ***permanent actions***.

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Thank you for your attention.