Basic concepts of assessment of existing structures

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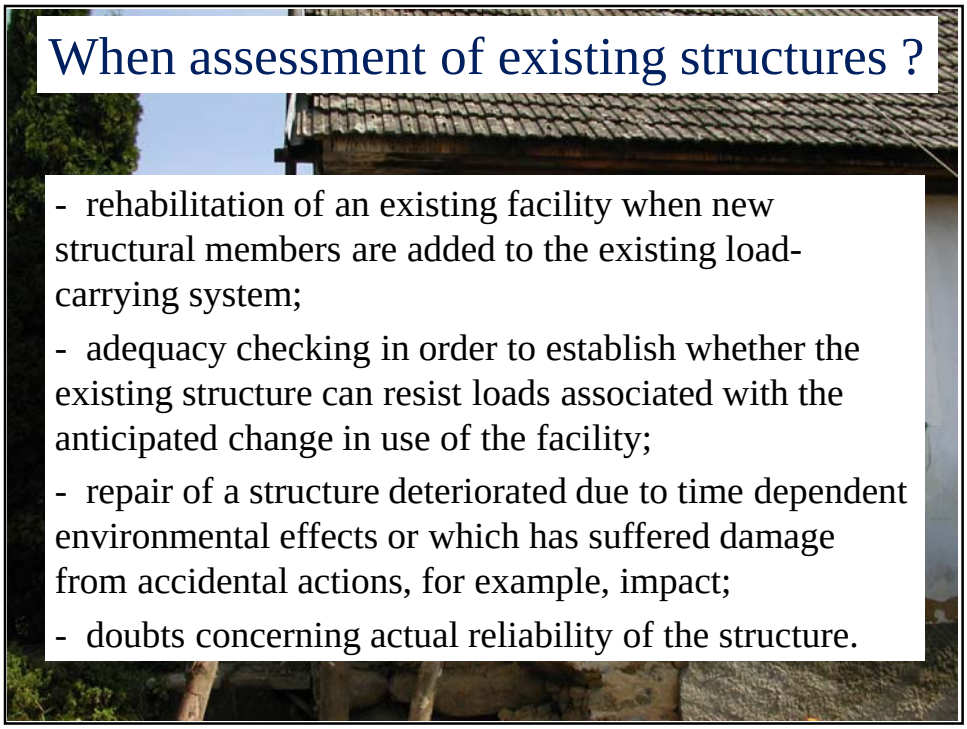
Background materials ISO, EN, JCSS

1. ISO 2394 General principles on reliability for structures, 1998
2. ISO 13822 Assessment of existing structures, 2008
3. ISO 13823 Design for durability, working draft
4. ISO 13824 Risk Assessment, working draft
5. ISO 12491 Statistical methods, 1997
6. EN 1990 Basis of structural design, 2002
7. EN 13791 Assessment of in-situ compressive strength in structures and precast concrete components, 2007
7. JCSS- RILEM Probabilistic Assessment of Existing Structures, 2001
8. JCSS Probabilistic Model Code, working draft
9. JCSS new activities on risk assessment a robustness, working drafts
10. FIP model code, 2007



When assessment of existing structures ?

- rehabilitation of an existing facility when new structural members are added to the existing load-carrying system;
- adequacy checking in order to establish whether the existing structure can resist loads associated with the anticipated change in use of the facility;
- repair of a structure deteriorated due to time dependent environmental effects or which has suffered damage from accidental actions, for example, impact;
- doubts concerning actual reliability of the structure.

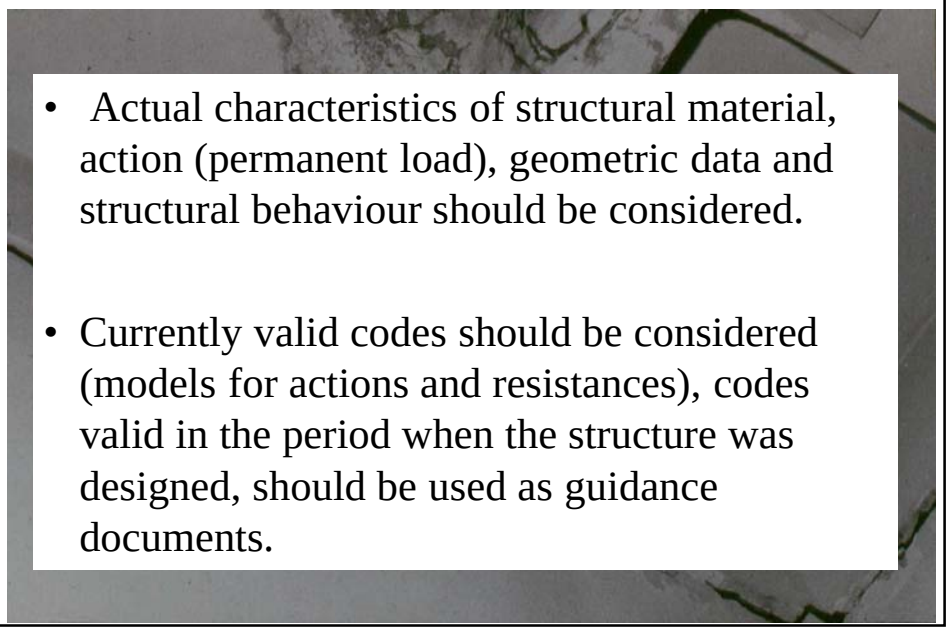
General aspects

Assessment is in many aspects different from designing a new structure
ISO 13822

The following aspects seems to be the most significant:

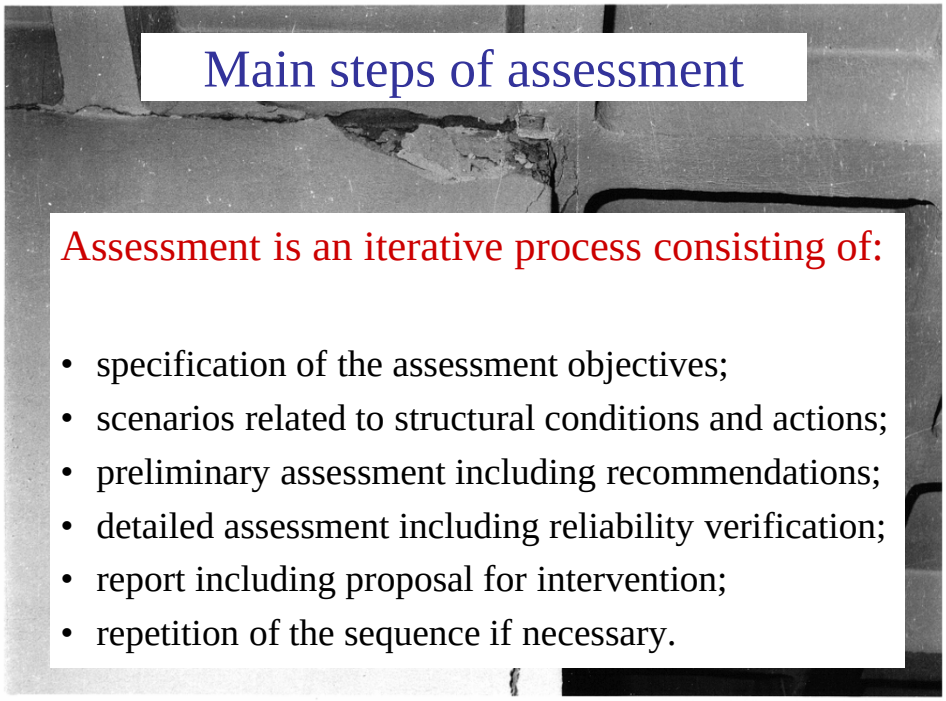
- effect of construction, alterations, misuse;
- past performance, damage, deterioration, maintenance;
- actual actions, geometry and material property;
- reliability differentiation (consequences, cost of safety measures, societal, political and culture aspects).

Two main principles



- Actual characteristics of structural material, action (permanent load), geometric data and structural behaviour should be considered.
- Currently valid codes should be considered (models for actions and resistances), codes valid in the period when the structure was designed, should be used as guidance documents.

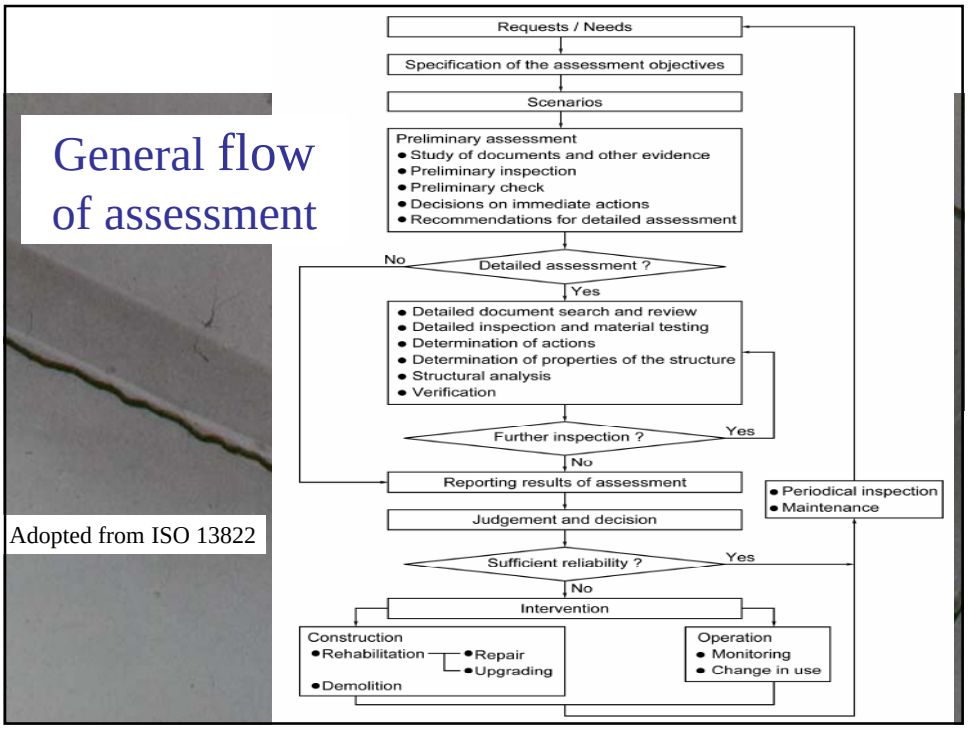
Main steps of assessment



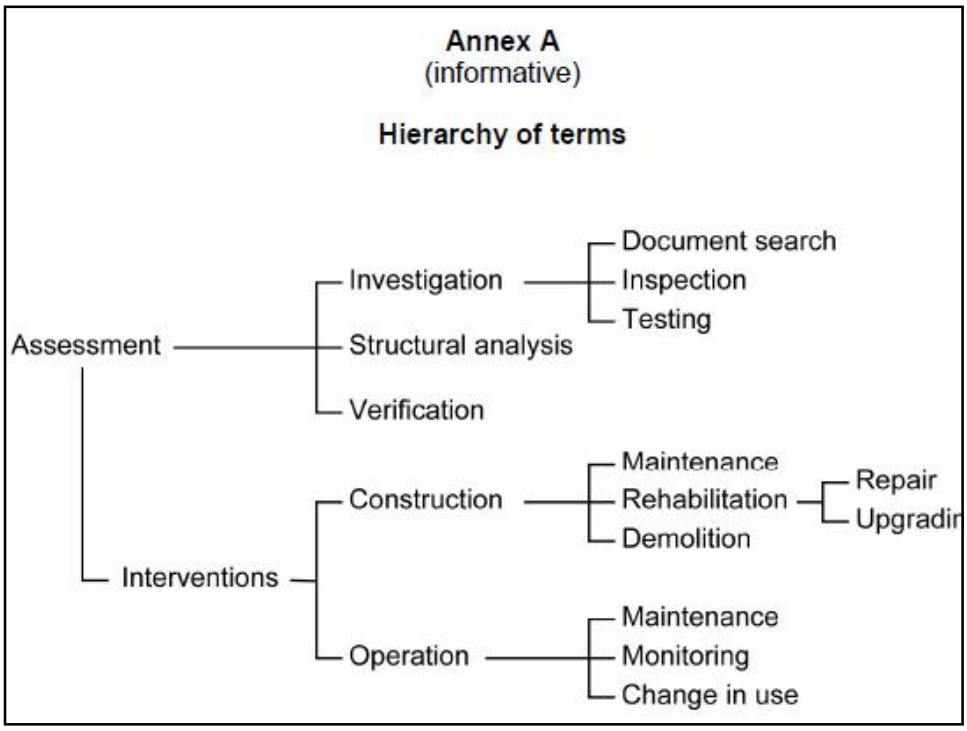
Assessment is an iterative process consisting of:

- specification of the assessment objectives;
- scenarios related to structural conditions and actions;
- preliminary assessment including recommendations;
- detailed assessment including reliability verification;
- report including proposal for intervention;
- repetition of the sequence if necessary.

General flow of assessment



Adopted from ISO 13822

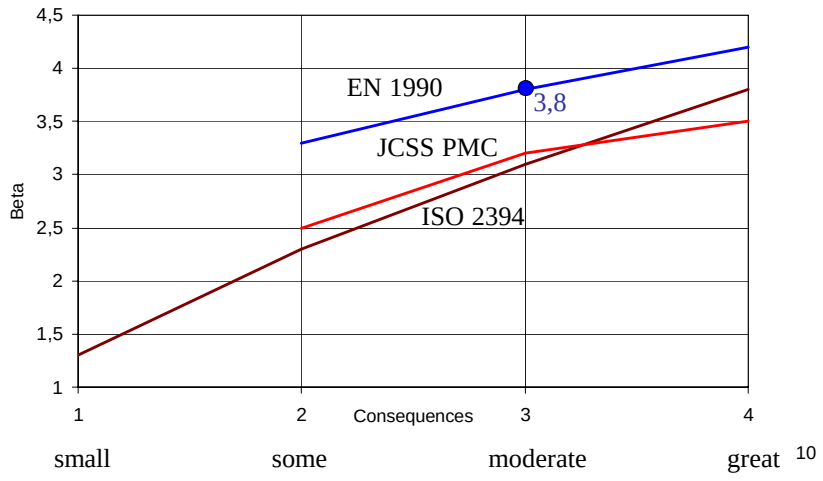


Target reliabilities indicated in ISO 13822

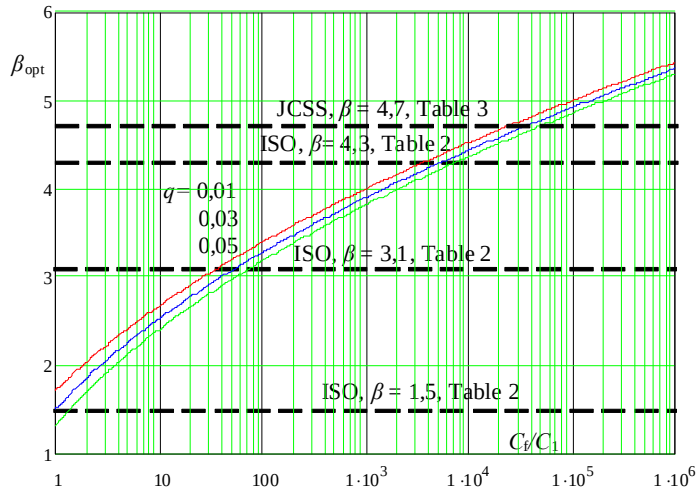
Limit states	Target reliability index, β	Reference period
Serviceability		
Reversible	0,0	Intended remaining working life
Irreversible	1,5	Intended remaining working life
Fatigue		
inspectable	2,3	Intended remaining working life
not inspectable	3,1	Intended remaining working life
Ultimate		
very low consequences of failure	2,3	L_S years*
low consequence of failure	3,1	L_S years*
medium consequence of failure	3,8	L_S years*
high consequence of failure	4,3	L_S years*
* L_S is a minimum standard period for safety (e.g. 50 years)		

Target β for the reference period 50 years

and “moderate” (ISO) or “normal” (JCSS) relative costs of safety measures



The optimum β_{opt} and target in ISO β



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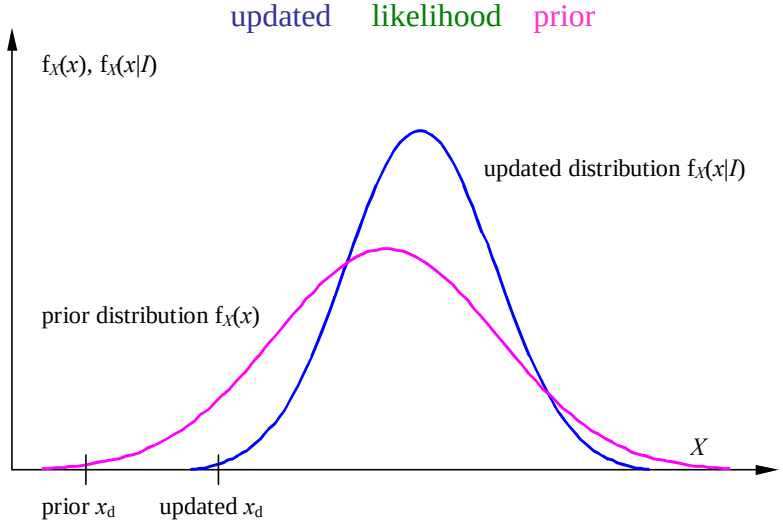
Probability and data updating

$$f_X(x|I) = C\, P(I|x)\, f_X(x)$$

updated likelihood prior



Partial factor

- Design value

for normal and lognormal distribution

$$x_{\mathrm{d}} = \mu(1 - \alpha\beta\, V)$$

for lognormal distribution: $x_{\mathrm{d}} = \mu\, exp\left(-\alpha\beta\, \sigma - 0.5\, \sigma^2\right)$

- Characteristic value

for normal $x_{\mathrm{k}} = \mu(1 - kV)$

for lognormal $x_{\mathrm{k}} = \mu\ exp\left(-k\, \sigma - 0.5\, \sigma^2\right)$

- Partial factor $\gamma_{\mathrm{m}} = \frac{x_k}{x_d}$

Assessment in case of damage

1) Visual inspection
2) Explanation of observed phenomena
3) Reliability assessment
4) Additional information
5) Decision if the reliability is still too low:

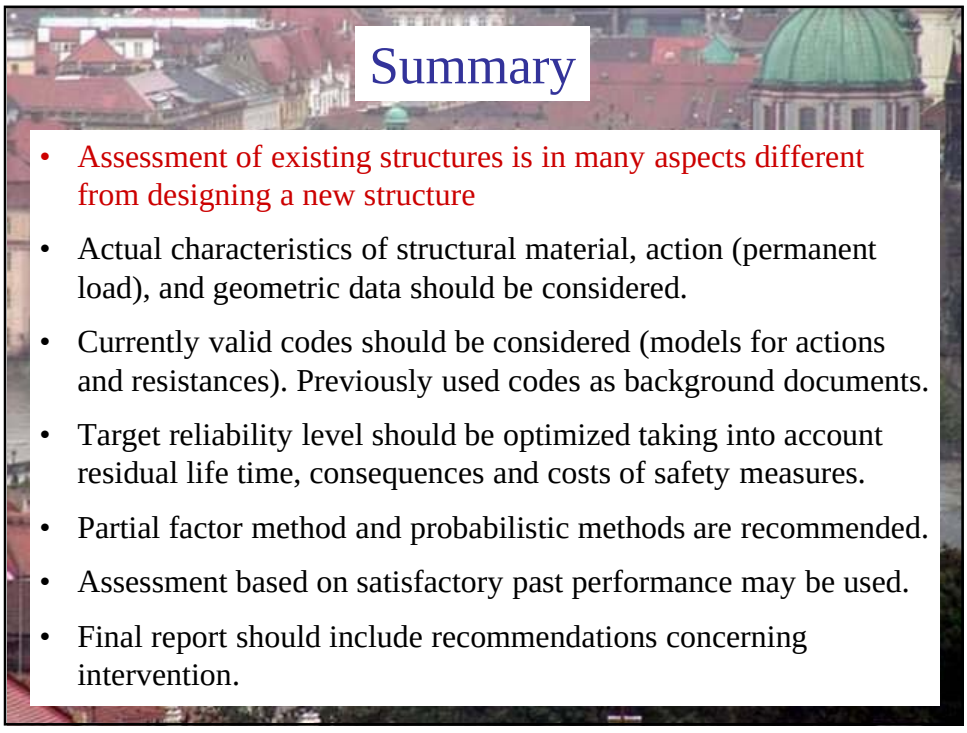
- accept the present situation for economical reasons;
- reduce the load on the structure;
- repair the building;
- start demolition of the structure.

The final report

The final report on structural assessment and possible interim reports (if required) should

- be concise and clear and should include
- clear conclusions with regard to the objective of the assessment
- based on careful reliability assessment and cost of repair or upgrading.

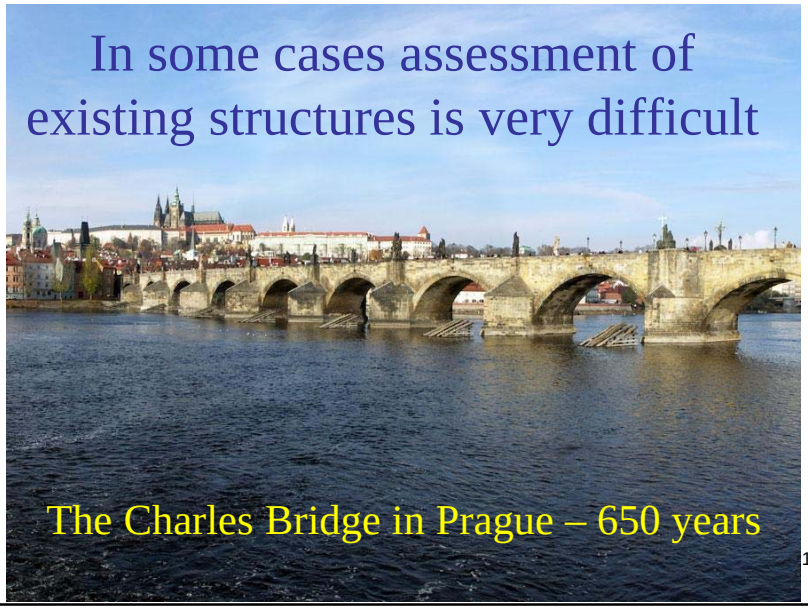
A recommended report format is indicated in Annex G to ISO/CD 13822 [2].



Summary

- Assessment of existing structures is in many aspects different from designing a new structure
- Actual characteristics of structural material, action (permanent load), and geometric data should be considered.
- Currently valid codes should be considered (models for actions and resistances). Previously used codes as background documents.
- Target reliability level should be optimized taking into account residual life time, consequences and costs of safety measures.
- Partial factor method and probabilistic methods are recommended.
- Assessment based on satisfactory past performance may be used.
- Final report should include recommendations concerning intervention.

Thank you for your attention - Gracias



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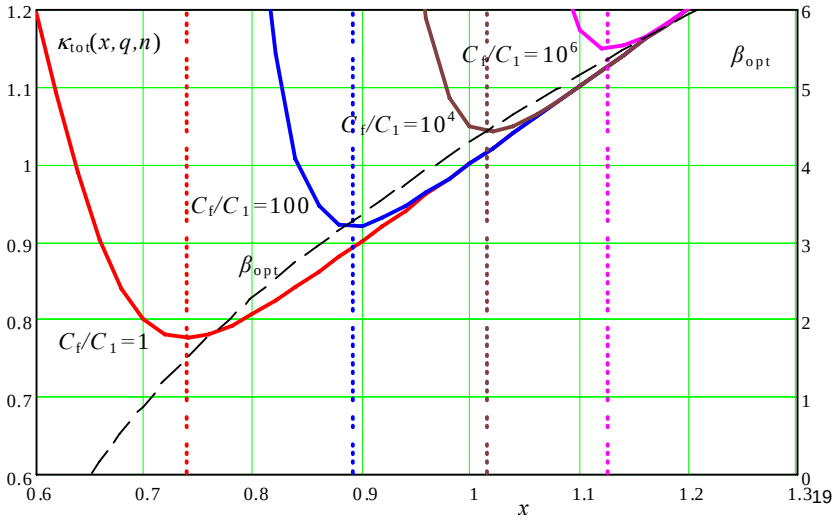
Motivation of the project

- Existing structures represent a huge economic asset getting larger and larger every year.
- Many existing structures do not comply with the requirements of the EUROCODES
- The assessment of existing structures requires knowledge beyond the scope of design codes for new structures.
- The ultimate goal is to limit construction intervention to a minimum, thus complying with the principles of sustainable development.
- Authorities, owners and engineers need guidelines how to deal with existing structures

The total cost $\kappa_{tot}(x,q,n)$ and reliability index β_{opt}

for q = 0,03 and n = 50 yeras



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The main issues to be considered

- Terminology of EN 1990 concerning assessment of existing structures (taking into account ISO documents).
- Operational rules of assessment linked to EN 1990 principles and ISO general provisions.
- Additional procedures not included in EN or ISO (e.g. estimation of permanent load of existing structures).
- Reliability differentiation for assessment of existing structures including heritage architecture (revisions of ISO).
- Probabilistic approach to assessment including reliability updating (detailed practical guidance).

Definition of the project Existing structures

Material independent document, linked to 1990

Foreseen main chapters

- Terms and definitions (additional terms to EN 1990)
- General framework (assessment procedures)
- Data for assessment (actions, materials, dimensions)
- Structural analysis (models, uncertainties, deterioration)
- Reliability verification (limit states, target reliabiloities)
- Assessment based on satisfactory past performance
- Interventions (alternative approaches)
- Report (inspection and maintenance)
- Annexes (updating, time dependence, target reliability, …)