JCSS

Joint Committee
on Structural Safety

Workshop on Assessment of Existing Structures

28th and 29th January 2021

Perspectives on Reassessment of Structures and Regulation

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Overview of Presentation

- On the need for probabilistic reassessment of structures
- A brief account of some developments in the past
- The basic concept of probabilistic reassessment of structures
- Potentials and challenges associated with standardization
- On the ”near future” impact of Industry 4.0
- Summary and closure

On the Need for Probabilistic Reassessment

Existing structures at global scale (selected sample)

- 500 cities with more than 1 million inhabitants
- 6 billion buildings
- 13 million km of roads
- 1 million km of railways
- 50,000 airports
- 45,000 dams
- 340,000 wind turbines
- 6,500 offshore oil and gas production platforms
- 440 nuclear reactors

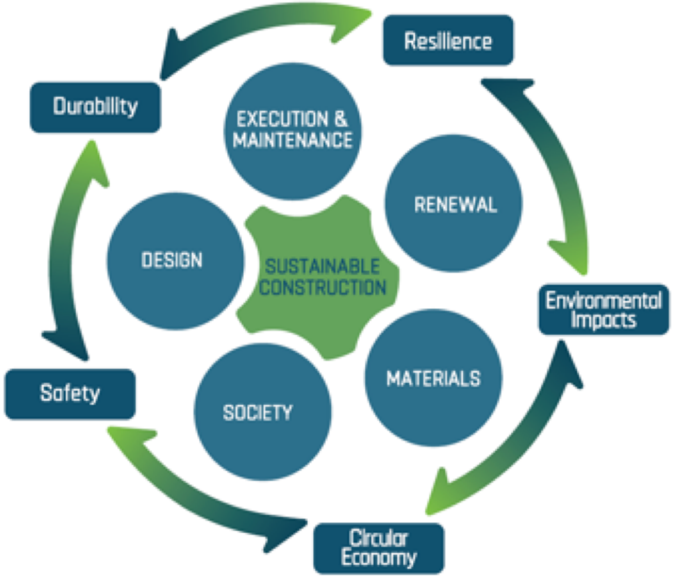
On the Need for Probabilistic Reassessment

The built environment alone

- Contributes with ~10% of GDP
- Responsible for 50% of global energy consumption
- Structures responsible for ~20% of global CO2 emissions
- Concrete responsible for ~8% of global CO2 emissions
- Responsible for ~90% of global material consumption (weight)

On the Need for Probabilistic Reassessment

GLOBE Consensus on Sustainability in the Built Environment



Nothing less than a transformative and united worldwide effort from all stakeholders of the construction sector is required for human society to be successful in sustainable development, and in the mitigation of the disastrous consequences of climate change at global and local scales.

http://globe.rilem.net

On the Need for Probabilistic Reassessment

GLOBE Consensus Actions (extract of)

- The civil engineering community must commit to addressing the sustainability challenge, and engage in and explore the potentials of new and emerging technologies in the pursuit of sustainable development.
- Design and integrity management of structures must be robust, and ideally modular and flexible to changes in use and functionality.
- Advances in information technology and structural health monitoring must be exploited to improve the sustainability of the built environment
- Design codes must be developed or revised such as to facilitate and reward the use of advanced analyses and methods of structural reliability, such as plastic analysis, probabilistic assessments of durability, and site-specific assessments of environmental loads.

A Brief Account of Developments

Research efforts/achievements

The search string:

Reliability, Assessment, Existing Structures

returns

3.6 million entries in Google Scholar

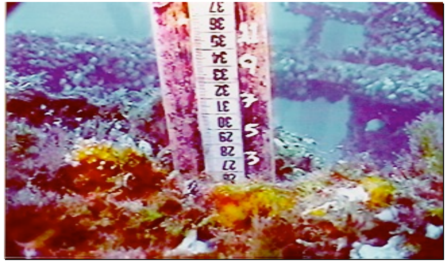
A Brief Account of Developments

Industry use of probabilistic reassessment (just a few)

Gudenå piledeck
Requalification, 1993

Old Lillebæltsbro
Requalification, 1994

Zarate Brazo Largo
Cable rehabilitation, 1995



Danish offshore sector
Reassessment for marine growth managment, 1997

Buchan Alpha
Safety case, 2012

Frigg field, reassessment
for decommissioning, 1999

A Brief Account of Developments

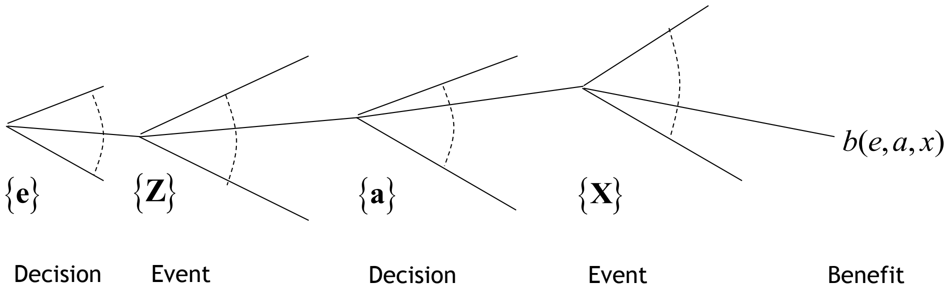
Standardization (selected activities)

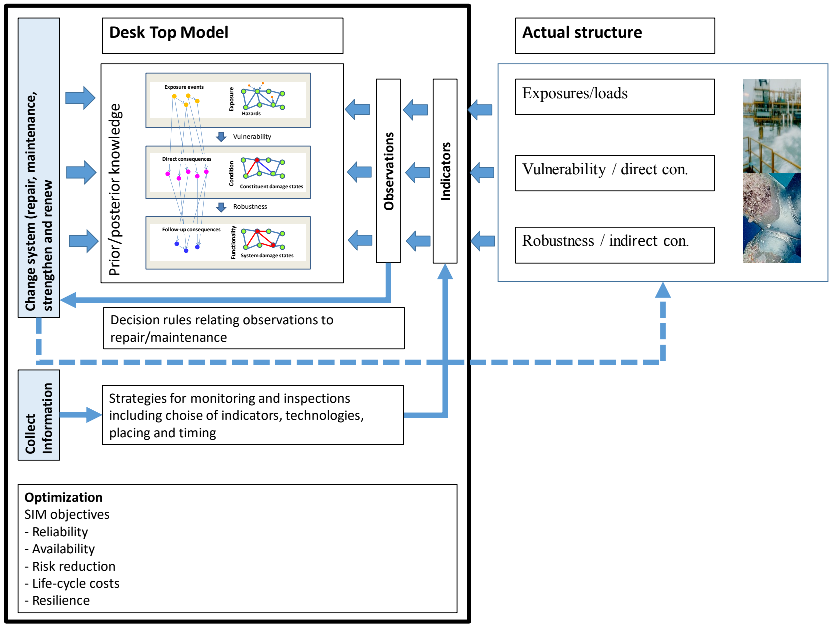
- Guideline for Reliability Based Assessment of Existing Highway Bridges, Danish Road Directorate, 1995
- Probabilistic Assessment of Existing Structures - JCSS Report, RILEM, 2001
- ISO 2394:1998/2015 – General Principles on Reliability of Structures
- ISO 13822: 2001/2010 – Bases for design of structures - Assessment of existing structures
- SIA 269 – Existing Structures, 2011

The Basic Concept of Probabilistic Reassessment

Structural integrity management

Bayesian decision analysis



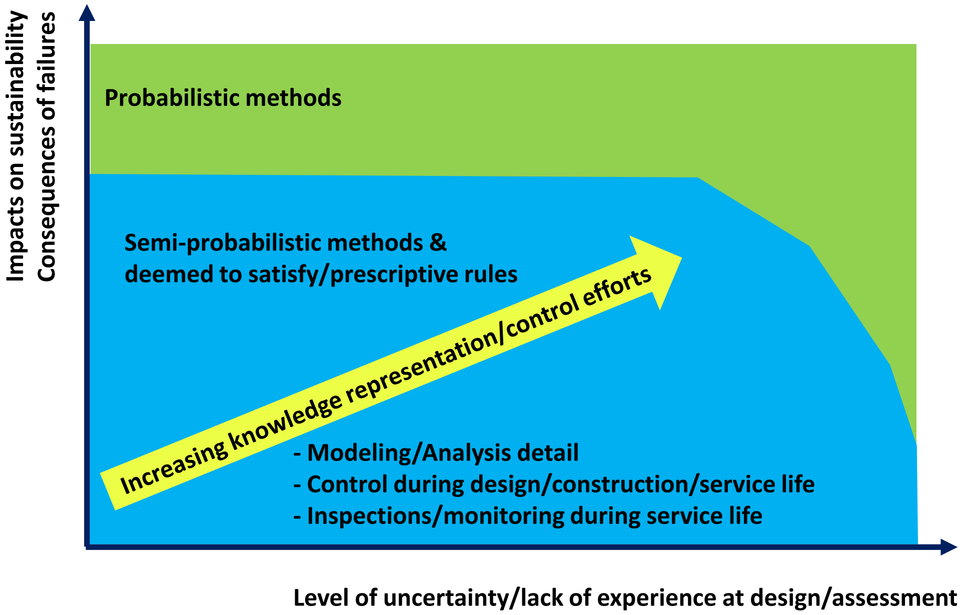


The optimal experiment e may be found from

$$B_1^* = \max_e E_{\mathbf{Z}}\left[\max_a \int b(e,a,x) f_X''(x,a|\mathbf{Z})dx\right]$$

The Basic Concept of Probabilistic Reassessment

Knowledge management in the context of Codes/Standards



Potentials and Challenges wrt Standardization

Potentials (selected)

- Substantially reduced need for renewals of the built environment
  - improved sustainability
  - enhanced service-life cost efficiency

- Improved safety/reliability/risk/resilience management
  - reducing loss of lives and/or damages to health and environment
  - information consistent accumulation of knowledge over time
  - enhanced engineering knowledge basis – also in the context of design

Potentials and Challenges wrt Standardization

Challenges (selected)

- There should be full consistency between Codes for design and Codes for reassessment, implying that;
  - an evidence based knowledge basis is established for design of structures
  - Codes for design must explicitly account for the effects of service life strategies on inspection and maintenance as well as monitoring
- Performances of structures over time depend strongly not only on the design and chosen materials but also on the quality of execution, the actually experienced loads, environmental exposures, use and maintenance, why;
  - assessment of existing structures relies on efficient and relevant collection and documentation of information – from cradle to grave
  - standardization must be made at generic/principal level – and users of standards must be able to understand and apply the principles – this must be appreciated in the profession and in educations

Impact of Industry 4.0

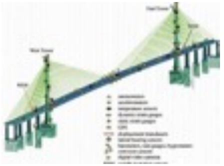
The main idea

- Transform all decisions in governance of the built environment into information mangement problems
- Apply new/merging technologies to provide decision support

Impact of Industry 4.0

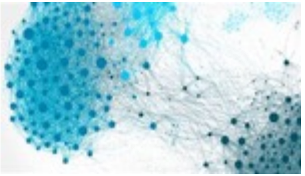
New and disruptive technologies

Digitalization



Monitoring

IoT



Big Data/AI

- **Digitalization**: Built environment may be virtualized
- **Monitoring**: Degradation, reliability and safety monitored
- **IoT**: Risk and security monitored and managed
- **Big Data/AI**: Integrity and sustainability management, forecasting and decision support

Impact of Industry 4.0

New possibilities for – sustainable - societal developments

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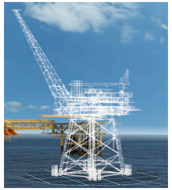
Design


Condition management


Reliability/resilience


Sustainability

AI augmented governance/management technology for

- Automated, evidence based design and integrity management of the built environment
- Sustainability management: Policy/project level validation
- Knowledge dissemination: VR object oriented education

Summary and Closure

- The methododical framework and toolboxes for probabilistic reassessment of structures is readily available:
  - it is scientifically sound
  - it has been proved by industrial use
  - several Standards and guidelines developed on this basis are already in function
- We need to ensure that the actual available knowledge comes into impact for enhancing governance and management of
  - Safety, reliability, risk and sustainability
- To me it appears more adequate that the potentials of Industry 4.0 – which inevitably will be exploited - are embraced by the engineering profession rather than technology providers (e.g. Google, Amazon, etc.)

Summary and Closure

- In the next 2 days, the topics I have only been able to touch upon will be elaborated by a number of experts and professionals with significant experience in the topics related to reassessment of existing structures
- I am sure that the presentations you will see will not only provide an interesting overview of what comprises corner stones and special insights in the topics but also trigger fruitful discussions and exchanges which will bring the potentials of probabilistic reassessment of existing structures into best practice
- Thanks for all the efforts of the initiators and organizers of this workshop and not least to all of you participating and contriuting to the discussions

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