Workshop on
"Climate resilience and design codes - factoring in climate projections"
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Climate change and future actions on infrastructure: User requirements

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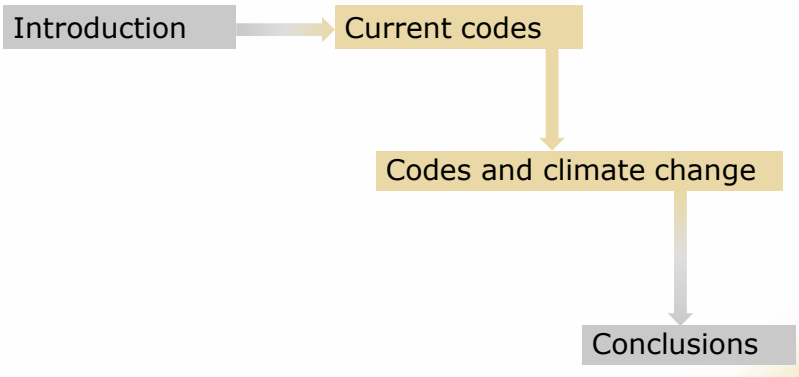
1

Outline



2

Which climate changes are most relevant for transportation infrastructure?

- USA
  - Increases in very hot days and heat waves (very likely)
  - Increases in Arctic temperatures (virtually certain),
  - Rising sea levels (virtually certain),
  - Increases in intense precipitation events (very likely), and
  - Increases in hurricane intensity (likely)
- Germany (no change scenario)
  - Increases in very hot days and heat waves
  - Increase in intense precipitation evens, although in average only moderate increase predominantly in summer
  - Slight or no reduction in moderate and extreme wind speeds
  - Both extreme low- and high-water level event in rivers and channels will increase.

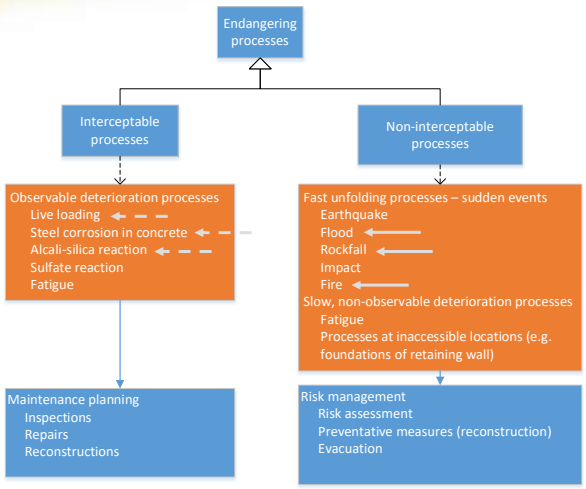
Current codes (and the reason we like them)

- Current code insulate engineers from complexity of environmental actions
- The actions on structures are defined in an accessible manner and can be directly used for design.
- The actions on structure are defined based on physical reality on a particular location
  - Wind loads
  - Earthquake
  - Flooding
  - Rockfall
  - Landslides
  - Avalanches
  - etc.

Is there anything wrong with this approach?

1. Existent Infrastructures
   - Given that the current codes are normally on the safe side, the potentially fit infrastructure may not meet the code requirements.
   - There is a need for more realistic models and more effort in assessing the fitness of existing infrastructure
   - **Reliability and risk approaches** are already used in assessment of existing infrastructure
   - The consequence application of these approaches require not only codes and guidelines but also robust data
2. Πάντα ῥεῖ
   - The deficits are more significant if the change over time needs to be adressed.
   - Traffic increase
   - **Climate change**

Endangering processes (or related actions)



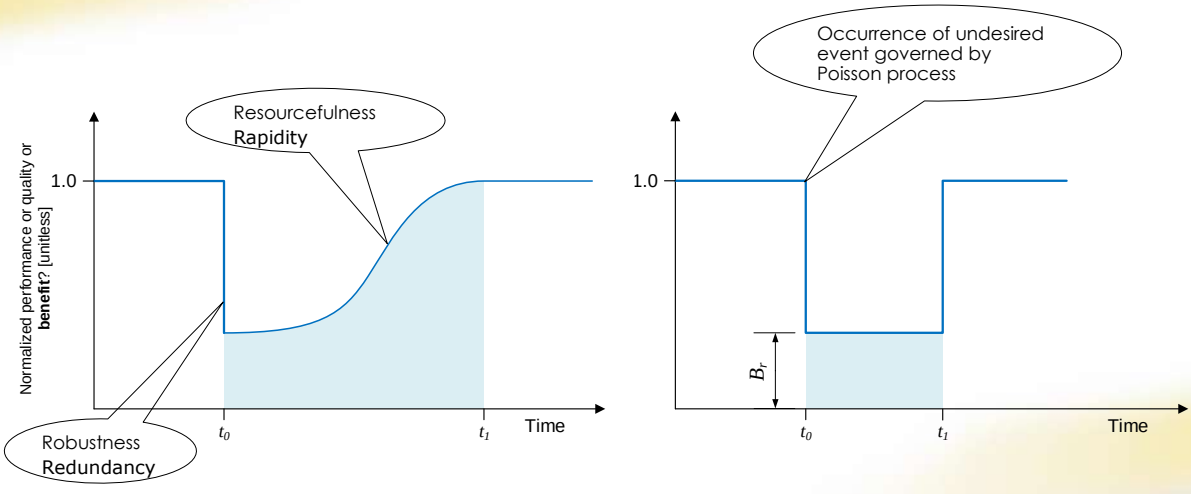
- Are these affected by climate change?
- To which degree?
- At which location?

- Is the impact of climate change direct or indirect?
- Do we need to investigate different scenarios?
  - Fossil forward
  - Green and lean

Low probability, high consequnces

- The codes are calibrated to ensure sufficiently low probability of undesirable event from occurring.
- This probability can be defined based on consequences.
- The targeted probability can depend on efficiency of interventions to achieve it.
- In essence it is a risk-based approach.
- The extension of this approach is to include time until the full functionality of infrastructure is restored in addition to consequences.
- This extension leads to resilience: it is governed by the functionality/benefit loss due to undesirable event and the time to restore full functionality.

Simple Example



Computing resilience

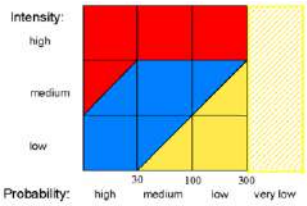
Return period = 20 years

What resilience aspects can to be covered in codes?

- Global approach -> Impact of interventions (technical, organizational, etc.) on resilience
- Maximum impact at minimum costs
- Paradigm shift from current prescriptive codes!

- Robustness (Resistance)☑
  - Strengthening
- Redundancy ☑
- Reduction of consequences
  - Design (e.g., elevating, displacing coastal roads, rail lines, and bridges)
  - Protection (e.g., protective structures, nets, sacrificial structures)
  - Regulation (e.g., zoning, restricted areas)

Relliable data



- Probability (return period) of different hazard intensities.
- Developed to evaluate risks to building.
- Scale 1:5000 in CH.

Different scenarios

- Climate protection measures
  - Increasing the efficiency of the transport system by making the most of digital technologies, smart pricing and further encouraging the shift to lower-emission transport modes;
  - Speeding up the deployment of low emission alternative energy for transport, such as advanced biofuels, electricity, hydrogen and renewable synthetic fuels, and **removing obstacles to the electrification of transport**;
  - **Moving to zero-emission vehicles**, while further improvements to the internal combustion engine (ICE) will be needed, Europe must accelerate the transition towards low- and zero-emission vehicles.
- Heavier vehicles, less payload
- Codes need to consider these loads.

Measures to increase resilience

- Mid- to long-term
  - All mentioned before
  - Robustness
  - Redundancy
  - Reduction of consequences
- Short-term / Emergency response
  - Reduction of consequences
  - Monitoring and early warning can prevent loss of life and property
  - Important for existing and increasingly exposed structures
  - Regulation or code requirements

PIARC Climate change adaptation framework

- Stage 1: Identifying **scope**, variables, risks and **data**
- Stage 2: Assessing and prioritizing risks
- Stage 3: Developing and selecting adaptation responses and strategies
- Stage 4: Integrating findings into decision making process

Conclusion

- Future codes need to be accessible and easy to understand
- The need for risk-based and resilience-based approach in particular for existing structures is evident.
- The application of such approach requires robust data on
  - threat scenarios for **a given location**
  - properties of infrastructure
  - consequence in case of failures and
  - **development of all above in course of time.**
- Data can be provided in a GIS as today.
- All relevant climate change scenarios should be addressed and tracked.
- Regulation on monitoring and emergency planning should be introduced.