Risk acceptance criteria for bridges

…and other large infrastructure objects

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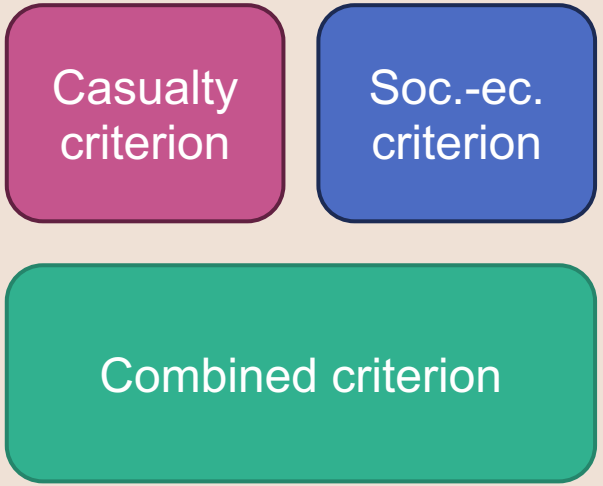
Types of criteria

Three main types

- Motivated by prevention of casualties
- Motivated by prevention of socio-economic consequences (loss of functionality, loss of asset itself)
- Combination of the above



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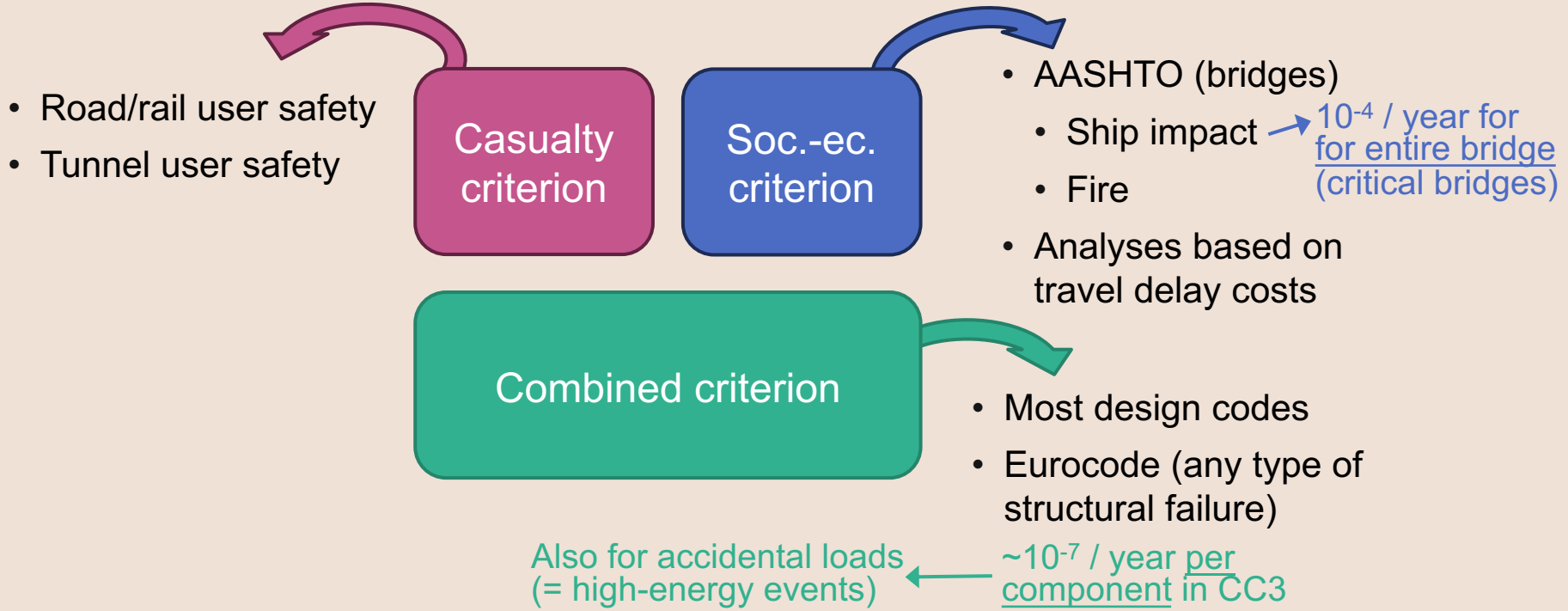

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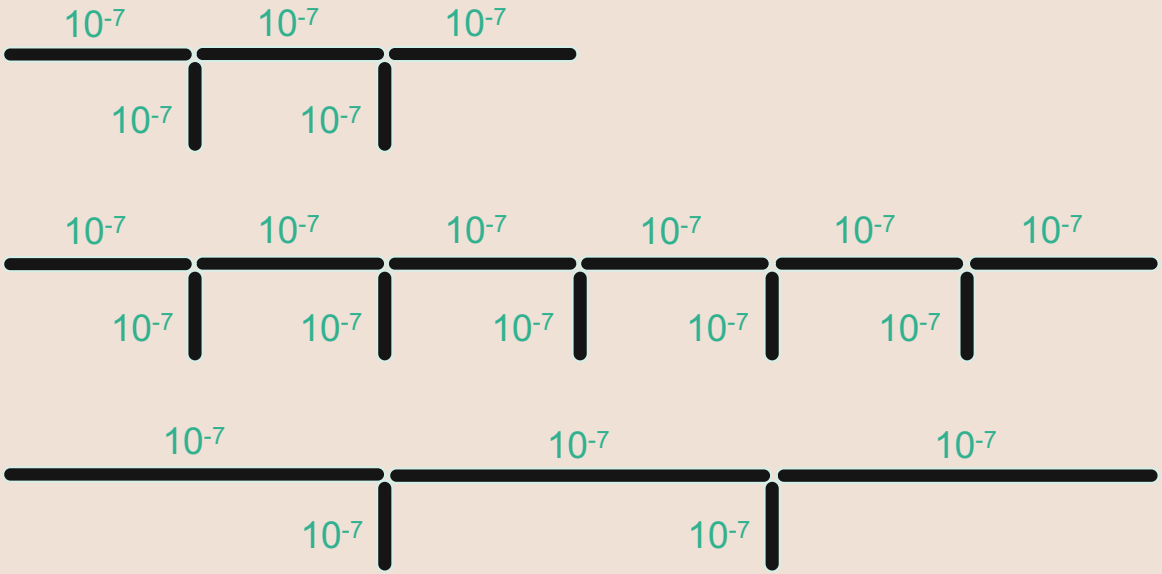
Ship impact Eurocode vs. AASHTO



Eurocode (if totalled)	AASTHO
5×10^{-7}	10^{-4}
1.1×10^{-6}	10^{-4}
5×10^{-7}	10^{-4}

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Danish bridges owned by Road Directorate & Banedanmark (rail)

New bridges (NA to EN 1991-1-7)

- Method I: 10^{-7} / year for structural failure due to accidental load
- Method II:
  - Road: 10^{-5} / year for events with large risk of loss of life + ALARP*)
  - Rail: 10^{-6} / year for events with large risk of loss of life + ALARP
  - Allowed to take measures reducing exposure of persons into account

Existing road bridges

- Method I: 10^{-6} / year for structural failure due to accidental load
- Method II:
  - 10^{-4} / year for structural failure + ALARP
  - 10^{-3} / year for structural failure if failure normally will not entail loss of life + ALARP

*) As low as reasonably practicable, based on cost-benefit analysis using willingness to pay to avert a fatality (“statistical value of life”)

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Norway

Accidental loads

- NA to EN 1991-1-7 (all structures)
- Handbook for bridge design N400
- Loads occurring less often than 10^{-4} / year can be ignored

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Great Belt Fixed Link

- Socio-economic criterion
  - 2×10^{-4} for disruption of entire link
  - 10^{-3} for disruption of road link
  - 10^{-3} for disruption of rail link
  - Approved by the transportation board of the Danish parliament
- Disruption risk is governed by high-energy events such as ship impact (bridges) and fire/storm surge (tunnel)
- Casualty criterion
  - Risk per passenger/vehicle-km as on average Danish road/rail section
- Casualty risk is governed by conventional traffic accidents
- High-energy events have been “disarmed” with respect to casualty risk

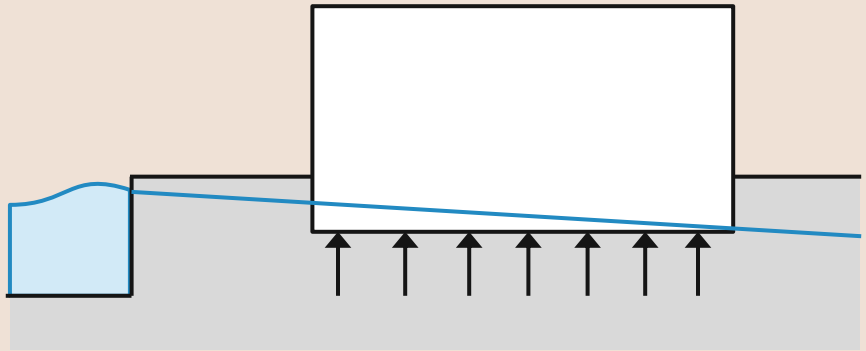
Other structures (Danish context)

Elderly, listed public building exposed to ground water pressure due to storm surge

- Risk: Failure of bottom slab, damage to facilities in the basement
- Water will not come suddenly

→ Loss of life is not the issue

→ Focus on socio-economic consequences instead of applying 10^{-6} / year blindly (Danish NA for buildings in CC3). What risk can the owner accept?



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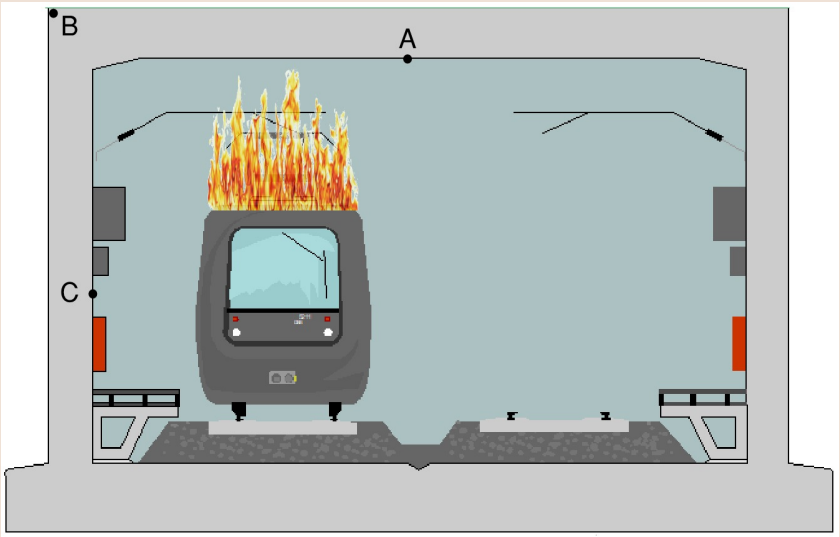
Other structures (Danish context)



Rail tunnel designed for passenger trains, will now soon be exposed to freight trains

- Placed at bottleneck in the European train network
- Fire risk, cut-and-cover slab with buildings on top
- Loss of life can occur in the early phase (<30 minutes)
- Disruption of the tunnel (collapse) can occur in the late phase (>60 minutes)

→ Risk acceptance criteria and risk-reducing strategy were handled separately

Conclusion

- 10^{-7} / year is a very harsh criterion when large infrastructure (high cost) is facing accidental loads (high energy)
- 10^{-7} / year does not differentiate in terms of the actual consequences
  - ALARP
  - Focus on actual consequences
  - If possible, define separate criteria for casualty risk and socio-economic risk