Symposium Eurocodes

Recent code devolopments and the relevance for structural designs and assessments in practice

Maurice Hermens, Advanced Technology & Engineering
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Open

NEN8700 – Ease of use

- Rapporteur: Bureau Hageman
- Goal: make the guidelines more clear and unambiguous
  - Structure of the norm
  - Relation with legal building requirements
  - Make a difference between
    - public legal requirements
    - private agreements
  - Take into account degradation

NPR9998-2018 developments

- Safety Philosophy
- NLPO
- Non-seismic structural elements
- Foundation & liquefaction

Safety philosphy - general

- ISO 2394
- Marginal Life Saving Costs
- ALARP

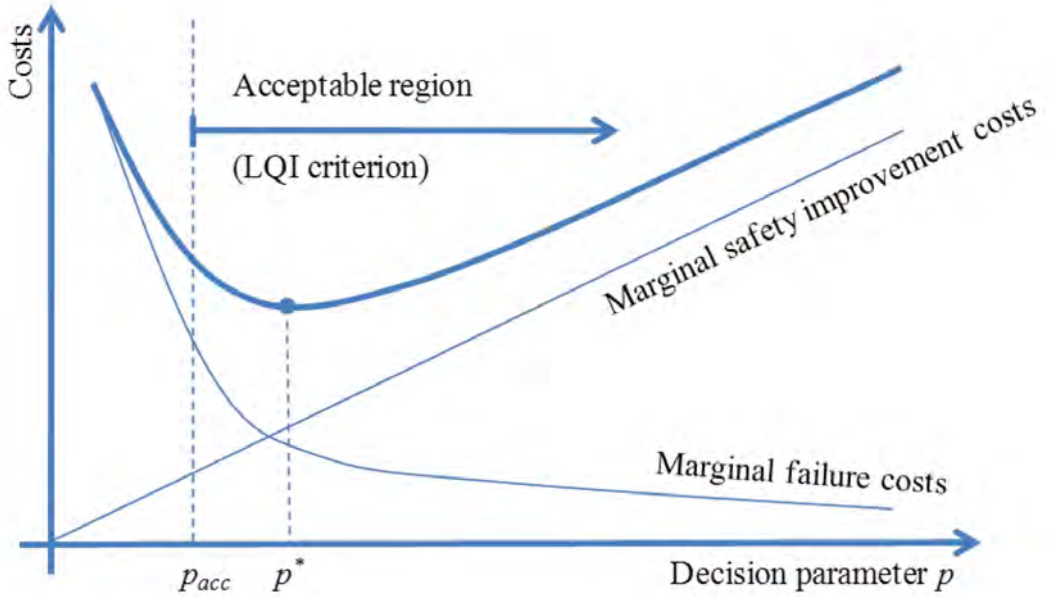

Figure G.2 — LQI acceptance criterion as a boundary condition for monetary optimization

Safety philosophy

Table 3.1. Tentative target reliabilities related to one year reference period and ultimate limit states, based on monetary optimization (ISO 2394 (2015))

Relative cost of safety measure	Consequences of failure		
	Minor	Moderate	Large
Large (A)	$\beta = 3.1 \left(P_f \approx 10^{-3} \right)$	$\beta = 3.3 \left(P_f \approx 5 \cdot 10^{-4} \right)$	$\beta = 3.7 \left(P_f \approx 10^{-4} \right)$
Normal (B)	$\beta = 3.7 \left(P_f \approx 10^{-4} \right)$	$\beta = 4.2 \left(P_f \approx 10^{-5} \right)$	$\beta = 4.4 \left(P_f \approx 5 \cdot 10^{-6} \right)$
Small (C)	$\beta = 4.2 \left(P_f \approx 10^{-5} \right)$	$\beta = 4.4 \left(P_f \approx 5 \cdot 10^{-6} \right)$	$\beta = 4.7 \left(P_f \approx 10^{-6} \right)$

$\beta = 1{,}0$	$P = 0{,}16$
$\beta = 2{,}0$	$P = 0{,}023$
$\beta = 3{,}0$	$P = 0{,}0013$
$\beta = 4{,}0$	$P = 0{,}000032$

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TNO Background document:

2.2 Veiligheidsfilosofie voor bestaande bouwconstructies

De veiligheidsbeoordeling van een bestaande constructie wijkt op een aantal

punten essentieel af van die van nieuwbouw:

- ten eerste brengt het verhogen van het veiligheidsniveau meestal relatief meer kosten met zich mee voor bestaande bouwwerken dan voor bouwwerken in het ontwerpstadium;
- ten tweede is de periode dat de constructie nog mee moet vaak anders dan de standaard ontwerplevensduur van 15 of 50 jaar
- ten derde bestaat de mogelijkheid om via metingen meer over een constructie te weten te komen.

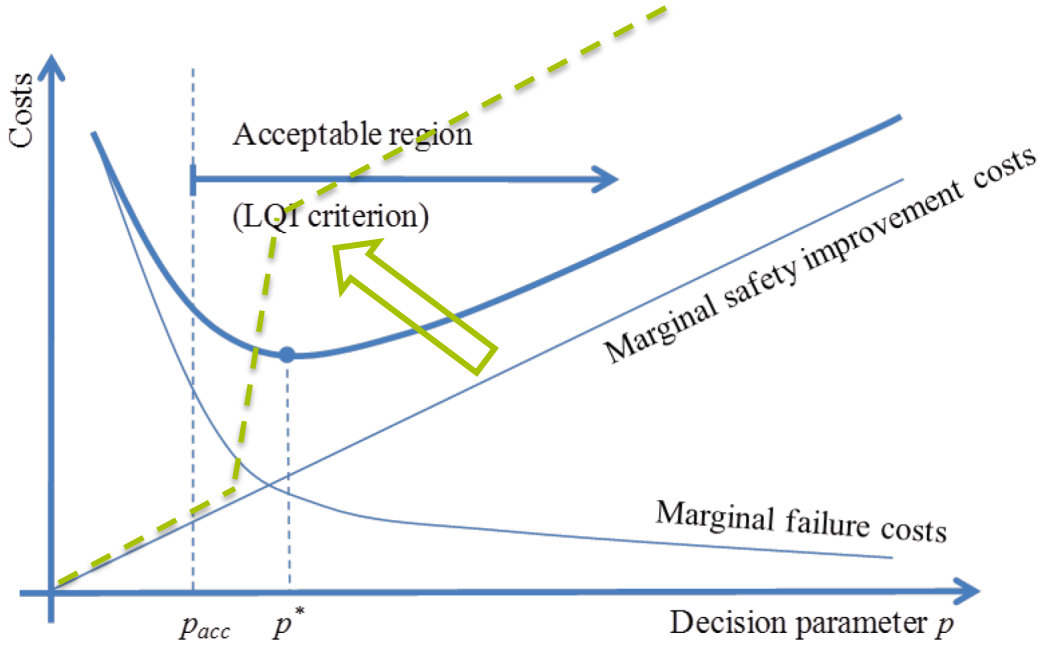

Figure G.2 — LQI acceptance criterion as a boundary condition for monetary optimization

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- 3 levels:
  - Nieuwbouw
  - Verbouw
  - Afkeuren

gevolg-klasse	Minimum referentie-periode	nieuwbouw β_n		verbouw β_r		afkeuren β_b	
		wn	wd	wn	wd	wn	wd
CC1A	1 jaar	3.3	2,3	2,8	1.8	1.8	0.8
CC1B	15 jaar	3.3	2,3	2,8	1.8	1.8	1.1*
CC2	15 jaar	3.8	2.8	3.3	2,5*	2,5*	2.5*
CC3	15 jaar	4.3	3.3	3.8	3.3*	3.3*	3.3*

* Hierbij is de ondergrens voor persoonlijke veiligheid maatgevend

- P(F)

$\beta = 1{,}0$	$P = 0{,}16$
$\beta = 2{,}0$	$P = 0{,}023$
$\beta = 3{,}0$	$P = 0{,}0013$
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P(d|F)

Gevolgklasse 1A: kans op levensgevaar nihil
Gevolgklasse 1B: kans op levensgevaar zeer klein $P_l = 10^{-3}$
Gevolgklasse 2: kans op levensgevaar aanzienlijk $P_l = 3\ 10^{-2}$
Gevolgklasse 3: kans op levensgevaar groot $P_l = 3\ 10^{-1}$

NPR9998-2018 – Safety Philosophy

- Individual Risk < 10^{-5}
  - The probability of death for an specified person as a consequence of a specified cause (in this report an earth quake in the Groningen region) in the period of one year.
- Note: Local Personal Risk (LPR):
  - The annual probability (or frequency) of death per year from specified causes for a hypothetical person located for 100% of the time at a specific location.
- Hazard > Collapse > Fatality
- IR = P(F) P(d|F)
- Note: P(F) represents P(collapse)

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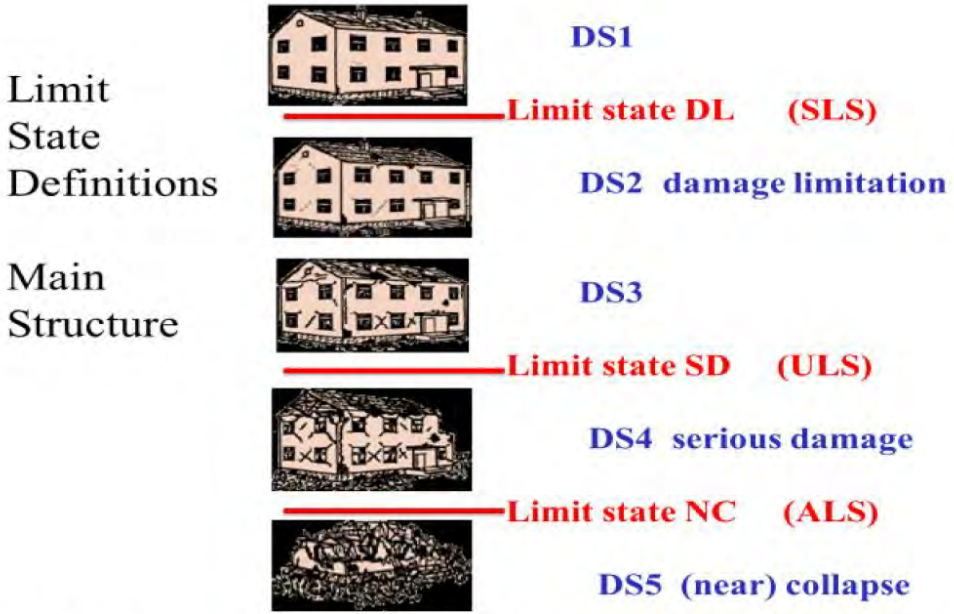

Figure 2.1 Global limit states NC, DS and DL according to the NPR 9998:2018 and damage stated DS1 to DS5 according to the Eurocode

NPR9998

- Near collapse limit state

The load bearing structure that ensures the stability of the building is heavily damaged, with low residual lateral strength and stiffness, although vertical elements are still capable of sustaining vertical loads. Most non-seismic structural elements and non-structural elements may have failed. Large permanent deformations are present. The load bearing structure is near collapse and would probably not survive another earthquake, even of moderate intensity.

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Figure 3.1: Three categories of volume loss

- IR = Σ P(FGi) P(d|FGi) + Σ P(FLj) P(d|FLj) < 10^{-5}
  - i =1: V = 20% P(V = 0.2|FG) = 0.90 P(d|V = 0.2) = 0.10
  - i =2: V = 50% P(V = 0.5|FG) = 0.09 P(d|V = 0.5) = 0.30
  - i =3: V =100% P(V = 1.0|FG) = 0.01 P(d|V = 1.0) = 0.50
- P(F) = P(V) $\cong$ .7 x 10^{-5}
- Near Collapse limit state
  - design earthquake return period 2475yr

Conclusions and discussion

- New Buildings economic motivations normative
  - A small extra investment will result in a large extra safety
  - Design philosophy in our education
    - “Making a ‘mistake’ is not a problem, as long as you know you are on the safe side”
    - “When you are not sure, err on the safe side”

- Existing Buildings personal safety normative
  - A small conservatism can have very large consequences (economically)
  - Assessment philosophy
    - Conservative approach can be very uneconomical
    - **Use the most realistic approach and assumptions**

- Note: Damage economic motivations normative, but similar approach

Conclusions and discussion

- New Buildings design
  - ‘Warning’ before collapse, no brittle behaviour
    - Equilibrium based structures
    - Minimum reinforcement
    - Reinforcement lapping in middle of beam
    - Achors
    - …
- Existing Buildings assessment
  - Building knowledge level > what to do in case of limited knowledge
  - Advanced calculations
  - Detailing
  - …