

Structural Reliability - the Practice and Background of EC3 Rules for Steel Structures

- General Remarks and Historical Perspective
- Current Practice and RFCS Project „Safebrictile"
- prEN1993-1-1 Annex E and TC459-SC3-WG9

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Development of Materials, Joining Techniques and Safety Concepts

	Time period and safety concept	Construction and Joining Techniques	Higher End of Used Yield Stresses f_y [MPa]
~ 1930	Basis: ultimate stress f_u „welding factors" φ $\sigma_{allow} = f_u \cdot \varphi / 3{,}0 \sim 140$ Mpa	Mostly Riveting	~240
~ 1950	Basis: yield stress f_y $\sigma_{allow} = f_y / k$ k around 1,7	Riveting + Gas Welding + First major uses of electrode Welding	~400
~ 1970	Allowable stresses, differentation of cases $\sigma_{allow} = f_y / C$ C: from 1,5 to 1,7	modern welding techniques, wider us of composite structures	~550
~1990	Partial Factor Concept f_y/γ_{M1}; f_u/γ_{M2}; $\gamma_{M1}=1{,}1$; $\gamma_{M2}=1{,}25$		
~ 2005 Eurocodes	Partial Factor Concept $f_y/\gamma_{M0/1}$; f_u/γ_{M2}; $\boldsymbol{\gamma_{M0/1}=1{,}0}$ **to 1,1**; $\gamma_{M2}=1{,}25$	High-Strength Steels	~700+

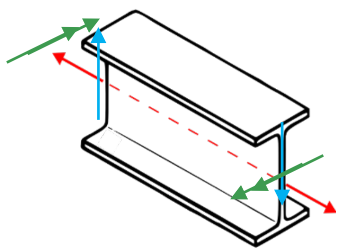
For standard steel grades up to S420, around 70 years of experience with essentially the same notional "safety level"

(provided the action side was representative)

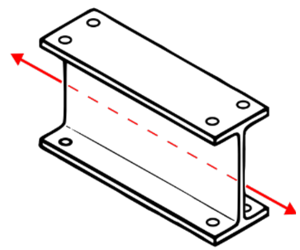
Basic Concepts of Eurocode 3 Design

- Steel Structures are designed against various "**limit states**" (failures)

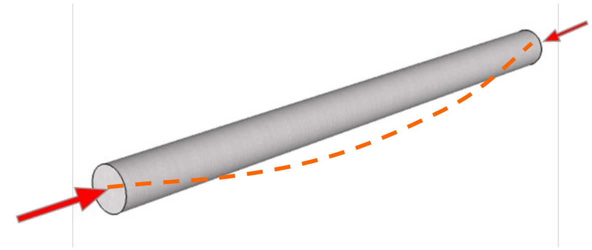
cross-section
yielding / plastic failure



net section
rupture / fracture

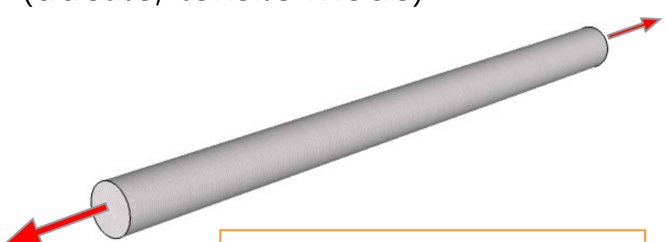


compression members
buckling



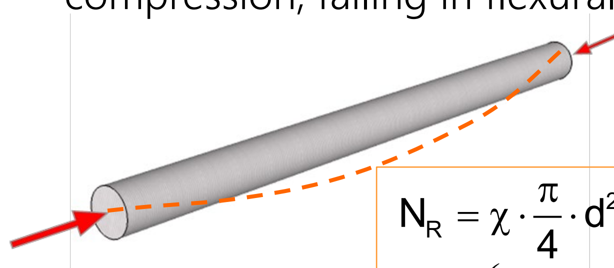
- Resistances in the limit states are described by "resistance functions"

Simple case:
resistance function for a tension rod failing in gross section yielding (ductile, tensile mode)



$$N_R = \frac{\pi}{4} \cdot \underbrace{d^2}_{\text{geometry}} \cdot \underbrace{f_y}_{\text{material}}$$

More complex case:
resistance function for the same rod in compression, failing in flexural buckling



$$N_R = \chi \cdot \frac{\pi}{4} \cdot d^2 \cdot f_y$$

$$\chi = f\left(\underbrace{\lambda}_{\text{slenderness}} ; \underbrace{L_{cr}}_{\text{buckling length}} ; \underbrace{e_0}_{\text{imperfections}} \right)$$

BASIC CONCEPTS OF EUROCODE 3 DESIGN

- Design Values of the “Resistance Functions“ in EN 1990

  - VAR 1: $$r_d = \frac{1}{\gamma_{Rd}} \cdot r\left(\eta_j \cdot \frac{\underline{X}_{k,j}}{\gamma_{m,j}}; a_d\right) \quad \text{with } j=1\text{.... k}$$

  - VAR 2: $$r_d = r\left(\eta_j \cdot \frac{\underline{X}_{k,j}}{\gamma_{M,j}}; a_d\right) \quad \text{with } j=1\text{.... k} \qquad ; \underbrace{\gamma_{M,j} = \gamma_{Rd} \cdot \gamma_{m,j}}_{\text{model + material uncertainty}}$$

  - VAR 3: $$r_d = \frac{r_k}{\gamma_M} = \frac{r(\underline{X}_{k,j})}{\gamma_M} \quad \text{with } j=1\text{.... k}$$

  - VAR 4: $$\boxed{r_d = \frac{r_{nom}}{\gamma_M^*} = \frac{r(\underline{X}_{nom,j})}{\gamma_M^*} \quad \text{with } j=1\text{.... k}}$$ used for steel structures

Basic Concepts of Eurocode 3 Design

- Design Resistances are thus defined as follows:

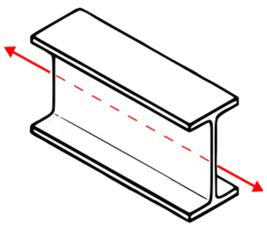
$$\boxed{R_d = \frac{\mathrm{R_{nom}}}{\gamma_{\mathrm{Mi}}}}$$

$\mathrm{R_{nom}}$... nominal resistance

$\mathrm{R_d}$... design resistance

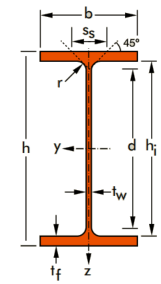
γ_{Mi} ... partial safety factor

- Nominal Resistance:



Example: yielding of a tension member

$$\boxed{\mathrm{R_{nom}} = \mathrm{N_{R,nom}} = \mathrm{A} \cdot \mathrm{f_y}}$$



  - area "A" and all dimensions according to catalogue (nominal values)
  - calculation value of yield strength f_y taken as either:
    a) the **minimum guaranteed values** of R_{eH} or $R_{p,0,2}$ from product standards (e.g. EN 10025-2)
    b) or a simplified table found in EN1993-1-1 itself (with fewer thickness steps)

- Present values of γ_{Mi}, currently specified in EC3 + NAs (National Annexes):

  γ_{M0} =1,0 to 1,05 for plastic failure and γ_{M1} =1,0 to 1,1 for buckling

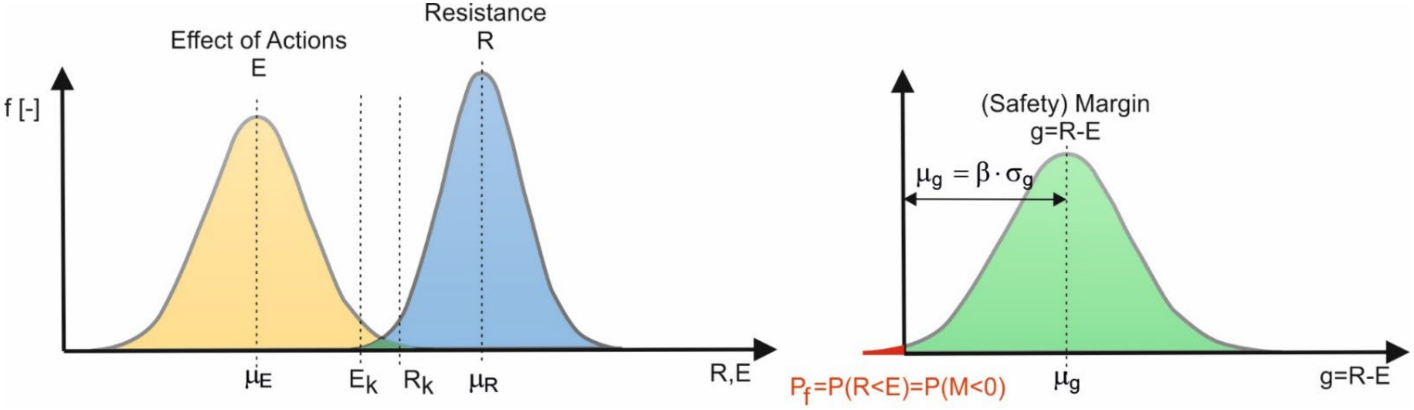
- For 2nd generation EC3 + NAs:

  γ_{M0} =1,0 = $\boldsymbol{\gamma_{M1}}$ **=1,0** - *accounting for some changes in e.g. buckling curves, some design equations*, validity of Annex E assumptions....

  Otherwise need to account for $\gamma_{M1} \geq 1{,}1$ for buckling.

BASIC CONCEPTS OF EUROCODE 3 DESIGN

- Structural Reliability – Definition in Eurocode / EN 1990 using factor β



Relation between the theoretical probability of failure P_f and β:

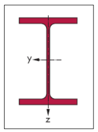
P_f	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}
β	1,28	2,32	3,09	3,72	4,27	4,75	5,20

For (steel) structures we have (since ENV-times) generally used β=3,8 and a distribution factor for the resistance side of α_R=0,8

→ 0,8 * 3,8=3,04

→ this implies: $P_{non\text{-}exceedance}$~$10^{-3}$ for resistance values

HOW COME $\gamma_{M0/1}$ IS SO LOW? (1.0 TO 1.1)?

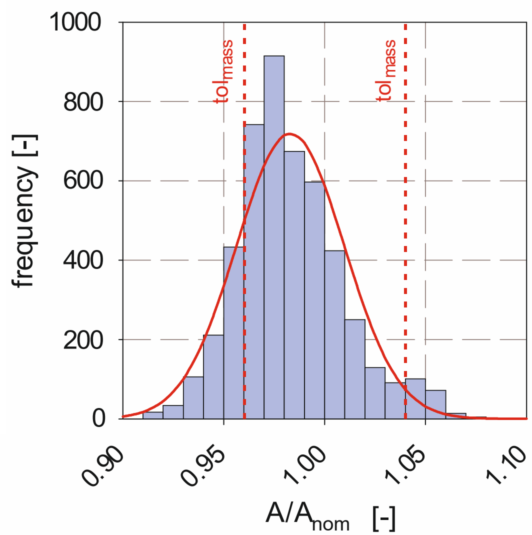


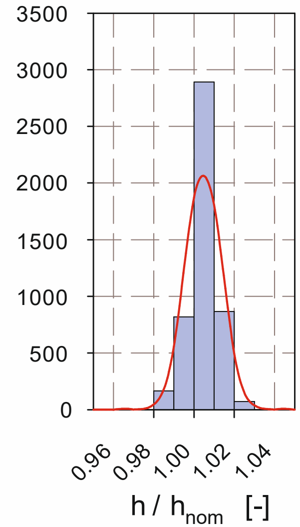
HE-profiles

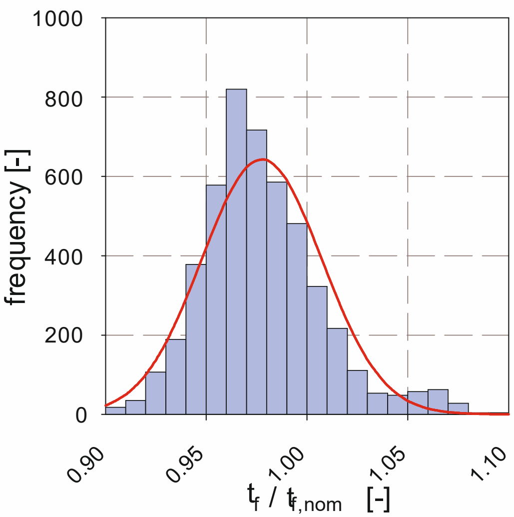
n=4816 measurements

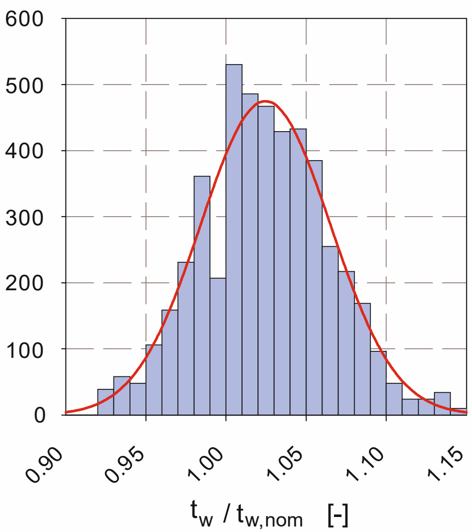
A/A_{nom}: m=0.985, s=0.027

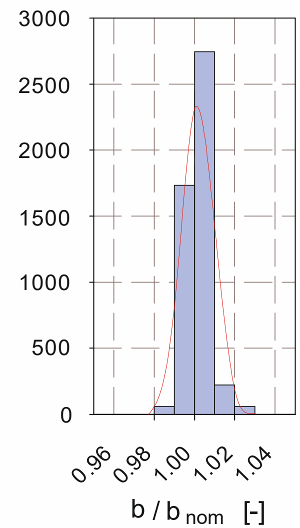
b/b_{nom}: m=1.00, s=0.009
h/h_{nom}: m=1.00, s=0.009
$t_f/t_{f,nom}$: m=0.975, s=0.03
$t_w/t_{w,nom}$: m=1.025, s=0.04











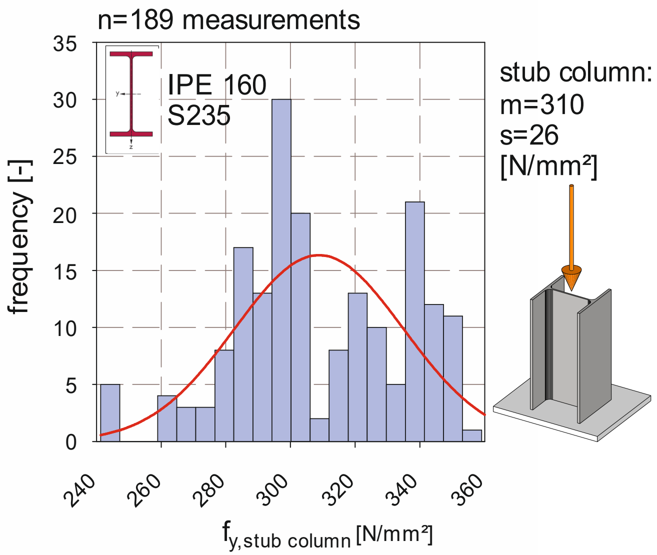
Geometry parameters actually tend to be ***slightly smaller*** than nominal values

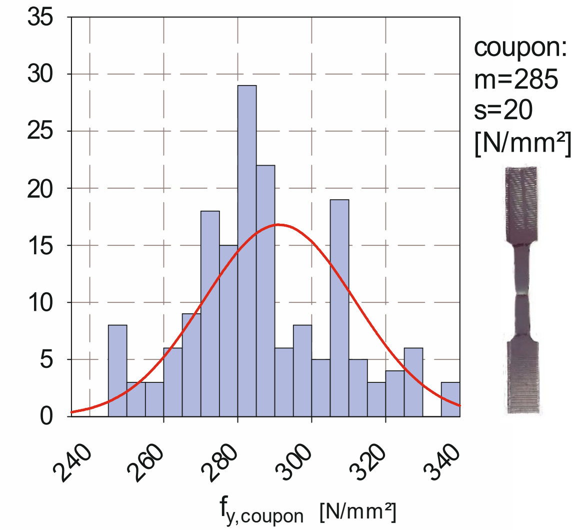
design calculations still mostly done with nominal values

→ this wouldn't lead to low γ values...

Data from Alpsten (1972), Variations in mechanical and cross-sectional properties of steel, Proc. ASCE-IABSE, Lehigh Univ.

HOW COME $\gamma_{M0/1}$ IS SO LOW? (1.0 TO 1.1)?





Yield Strength is however commonly **very significantly higher than the minimum guaranteed values**

→ γ_M can be close to 1.0

(Compare: concrete 1.5, timber ~1.3)

Assumptions: (prEN1993-1-1:2020 Ann. E)

Steel grade	$R_{eH,min} = f_{y,nom}$ [N/mm²]	$R_{eH,mean} / R_{eH,min}$	CoV
S235	235	1.25	5.5%
S355	355	1.20	5%
S460	460	1.15	4.5%

γ_M values thus defined as in EC3 to NAs

Check of gross sections, plastic capacity, … (Basic value: f_y)	γ_{M0}	1.00 to 1.05
Buckling (local, global, shell buckling) (Basic value: f_y)	γ_{M1}	1.00 to 1.10
Check of net sections, welds, bolts… (Basic value: f_u)	γ_{M2}	1.25

EVALUATION PROCEDURE (AS USED FOR 2ND GENERATION EC3)

Step 1

Resistance function – theoretical resistance $r_{t,i}$

$$r_{t,i} = g_{rt,i}(X_1, X_2 \ldots X_n)$$

The resistance function is a function of the selected relevant basic variables X_i

Experimental resistance
Experimental values $r_{e,i}$ for each test specimen (these results can be obtained from tests or numerical estimates from advanced simulations)

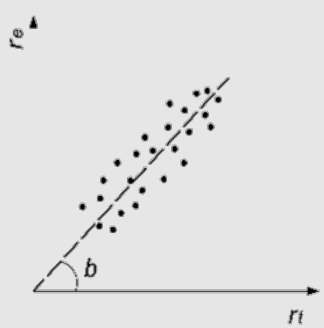
Basic variables
Pre-information is needed regarding the distributions of the basic variables $\mathbf{X_j}$: *mean value* $\mathbf{X_{jm}}$ and *standard deviation* $\boldsymbol{\sigma_j}$

Step 2

Estimate mean vale of correction factor *b*

$$b = \sum_{i=1}^{n} r_{e,i} r_{t,i} \Big/ \sum_{i=1}^{n} r_{t,i}^{\ 2}$$

The factor is a global value for the selected subset. The correction factor can be used as an indicator of the accuracy of the model, i.e. it should not strongly diverge from unity (0.85-1.15)



Estimate CoV of the model error:

$$\delta_i = r_{e,i} / b\, r_{t,i} \qquad \Delta_i = \ln(\delta_i)$$

$$s_\Delta^{\ 2} = \frac{1}{n-1} \sum_{i=1}^{n} \left(\Delta_i - \overline{\Delta}\right)^2$$

$$V_\delta = \sqrt{\exp(s_\Delta^{\ 2}) - 1}$$

The CoV of the model error is a global value for the selected subset and represents the difference between the model estimate and the experimental estimate.

From „SAFEBRICTILE" Final Report – Based on EN 1990 Annex D procedure

Evaluation Procedure (as used for 2nd Generation EC3)

Step 3 (for each specimen i)

Determine the coefficient of variation V_{rt} – it relates to the basic input variables:

i) In case of simple product function, the following expression is used: $V_{rt} = \sum V_{Xj}^{2}$

ii) In case of more complicated resistance function, V_{rt} can be obtained for each specimen as:

$$V_{rt,i}^{2} = \frac{1}{r_{t,i}\left(\underline{X_m}\right)^2} \sum_{j=1}^{k} \left(\frac{\partial r_{t,i}\left(X_j\right)}{\partial X_j} \sigma_j \right)^2$$

Often, it is complicated to use the analytical expression of the partial derivatives; a numerical estimate can be used instead. It can be determined from:

$$\frac{\partial r_{t,i}}{\partial X_j} \approx \frac{r_{t,i}(X_1,\ldots,X_j+\Delta X_j,\ldots.X_k) - r_{t,i}(X_1,\ldots,X_j,\ldots.X_k)}{\Delta X_j}$$

where ΔX_j is sufficiently small increment (see chart 2)

(*Note: See section 5 for simplifications and alternative implementations*)

Step 4 (for each specimen i)

Determine the design value of the resistance, for each test and $V_{rt,i}$

$$Q_i = \sqrt{\ln(V_\delta^{2} + V_{rt,i}^{2} + 1)}$$

$$r_{d,i} = b r_{t,i}(\underline{X_m}) \exp\left(-k_{d,\infty} Q_i - 0.5 Q_i^2\right)$$

Determine the partial safety factor, as a mean value from the safety factors for each specific case:

$$\gamma_{M,i}{}^* = r_{nom,i} / r_{d,i} \longrightarrow \gamma_M{}^* = 1/n \sum \gamma_{M,i}{}^*$$

From „SAFEBRICTILE" Final Report – Based on EN 1990 Annex D procedure

EVALUATION PROCEDURE (AS USED FOR 2ND GENERATION EC3)

- Comments to STEP 1:

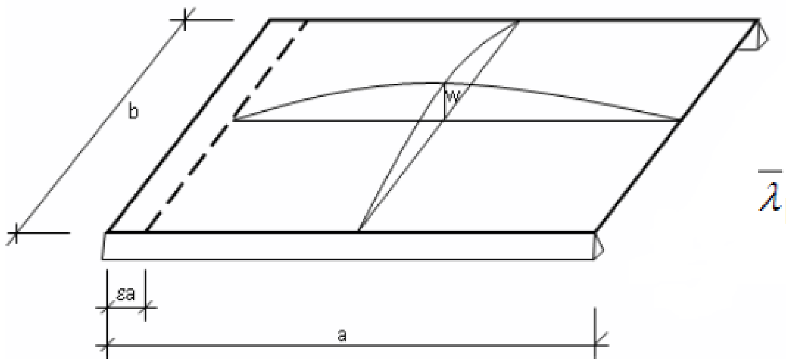
  - The resistance function represents the developed design method or formula; *only the parameters that enter the resistance function explicitly are "basic variables" of the safety factor evaluation.*

$$r_t = g_{r_t}(\underline{X}) = g_{r_t}\left(X_1,\ X_2,\ \dots,\ X_j,\ \dots,\ X_k\right)$$

e.g. *"Winter curve" = resistance function for plate buckling:*

t, b, f_y, E, BCs → enter r_t → basic variables for the procedure

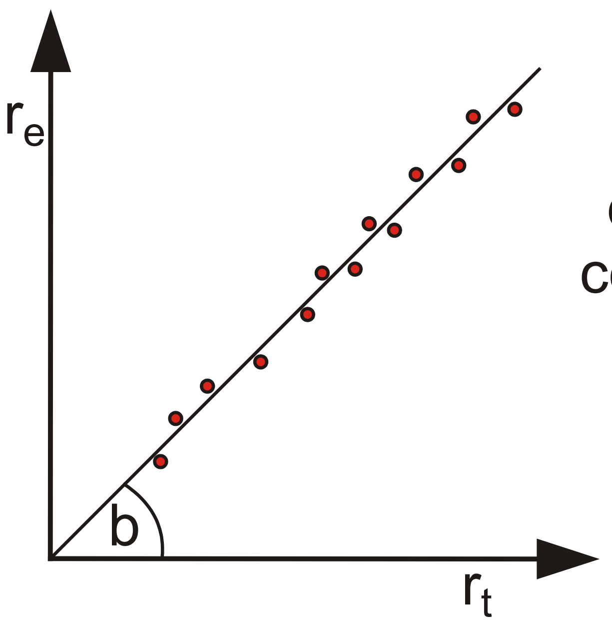
σ_{res}, w → *do not explicitly enter r_t* → *not* basic variables!



$$\bar{\lambda}_p = \sqrt{\frac{f_y}{\sigma_{cr}}} = \frac{\bar{b}/t}{28{,}4\ \varepsilon\ \sqrt{k_\sigma}} \qquad \rho = \frac{\bar{\lambda}_p - 0{,}055\,(3+\psi)}{\bar{\lambda}_p^2} \le 1{,}0$$

EVALUATION PROCEDURE (AS USED FOR 2ND GENERATION EC3)

- Comments to STEP 2:
  - Compare the experimental (or numerical) test results with the evaluation of the resistance function – evaluated with the individually measured values of the basic variables.



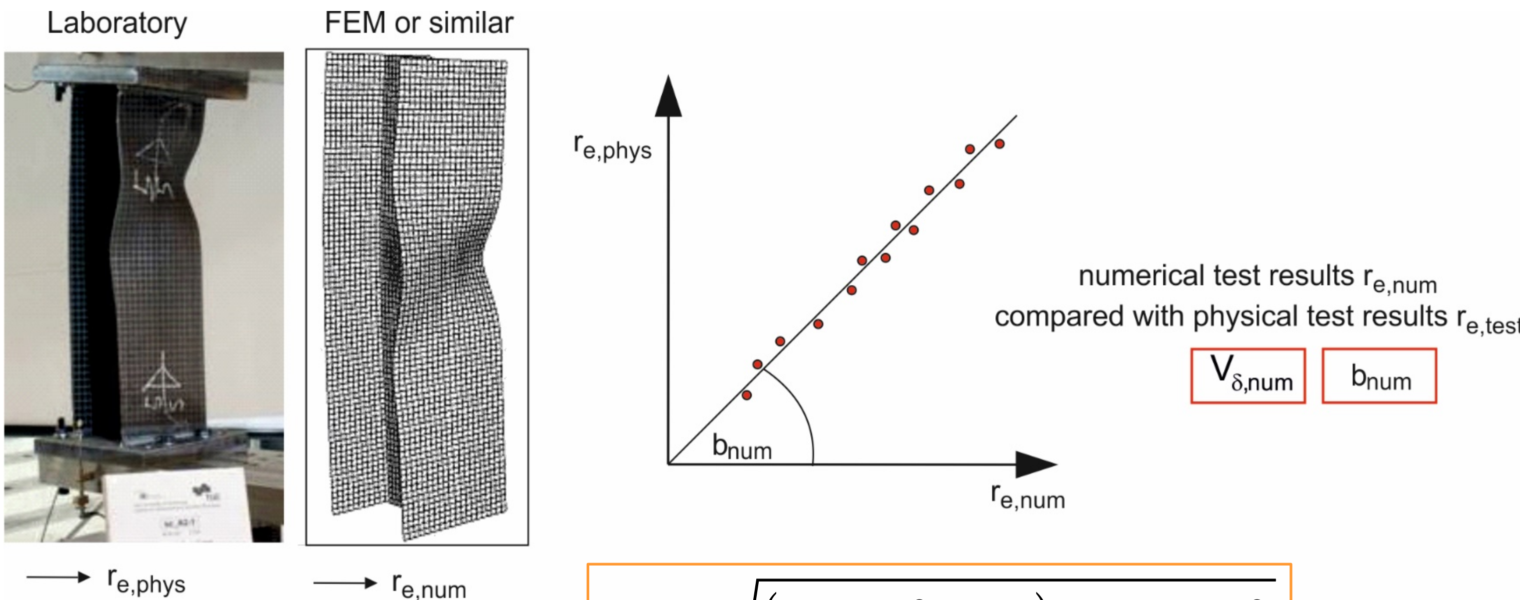
design model with measured input data compared with physica or numerical tests

$\rightarrow$ $\boxed{V_\delta}$

EVALUATION PROCEDURE (AS USED FOR 2ND GENERATION EC3)

- On the use of „Numerical Tests" in STEP 2:

  Widely used. However, while FEM is accurate, it is not "reality"
  → error term of numerical vs. physical test needs to be included



$$V_\delta = \sqrt{\left(\exp(s_\Delta^2) - 1\right) + V_{\delta,num}{}^2}$$

Exception for the study of "established" cases with accepted assumptions for FEM modelling, leading to a lower-bound estimate of strengths

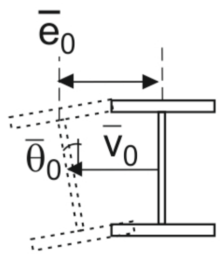
EVALUATION PROCEDURE (AS USED FOR 2ND GENERATION EC3)

- On the use of „Numerical Tests" in STEP 2:

Example for "established case": Column or Beam Buckling

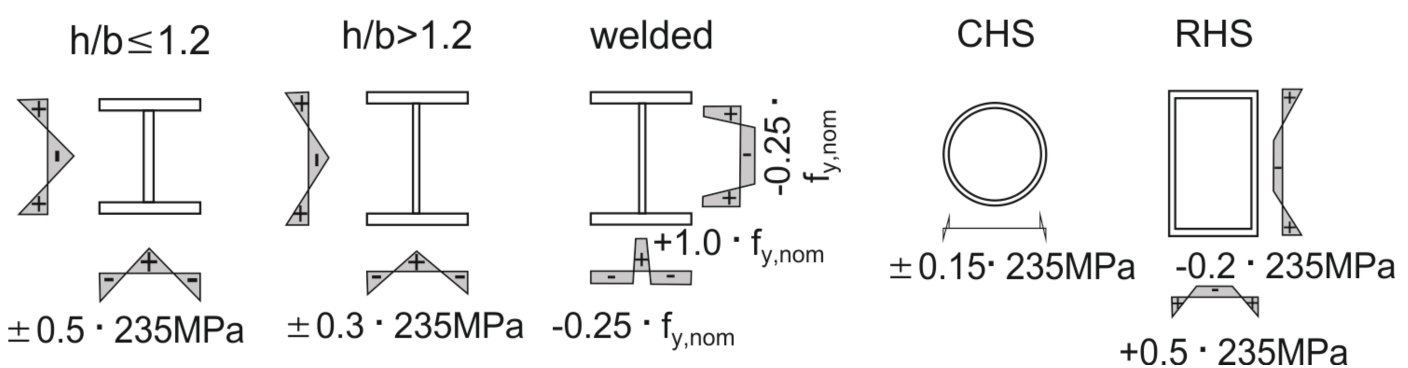
global geometric imperfections:

first eigen-mode or similar shapes



AMPLITUDE OF GLOBAL GEOMETRIC IMPERFECTION: $\boxed{\bar{e}_0 = L/1000}$

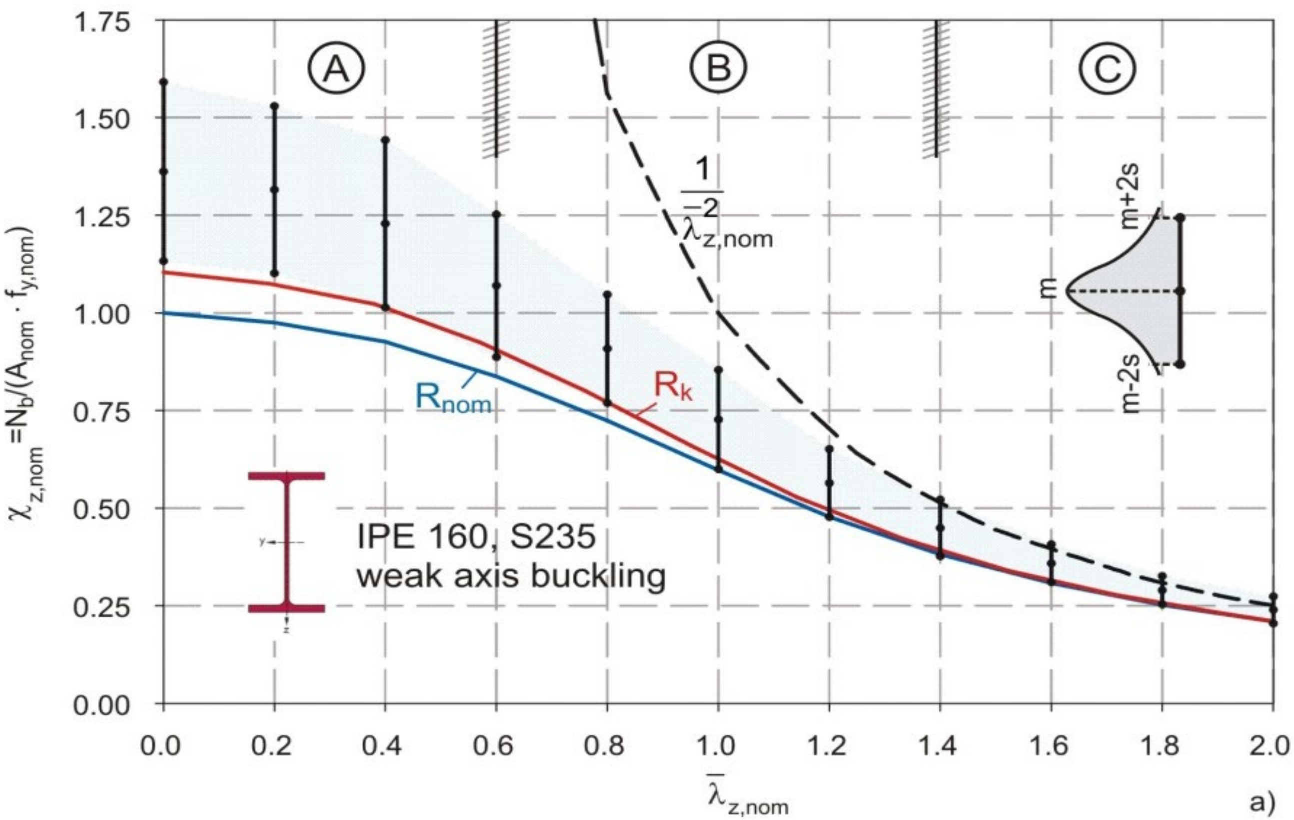
RESIDUAL STRESSES (see ECCS recc., 1984)



EVALUATION PROCEDURE (AS USED FOR 2ND GENERATION EC3)

- On the use of „Numerical Tests“ in STEP 2:

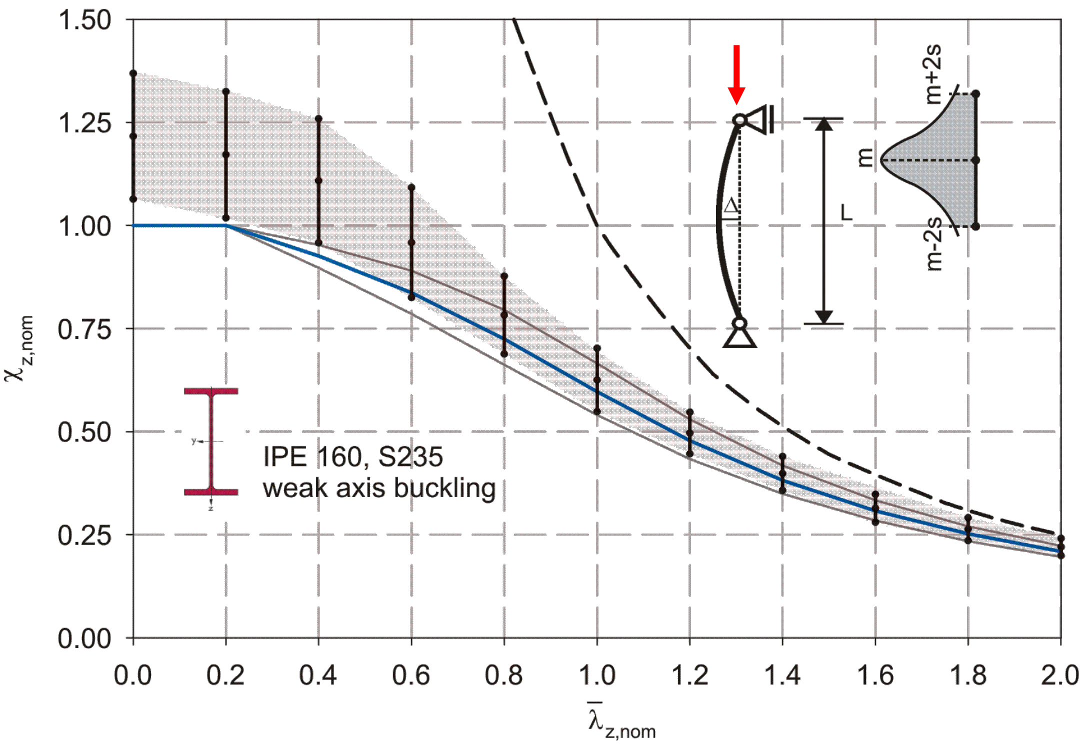
Example for “established case“: Column or Beam Buckling

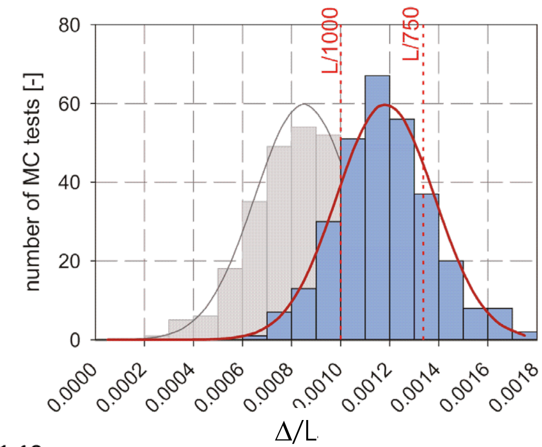


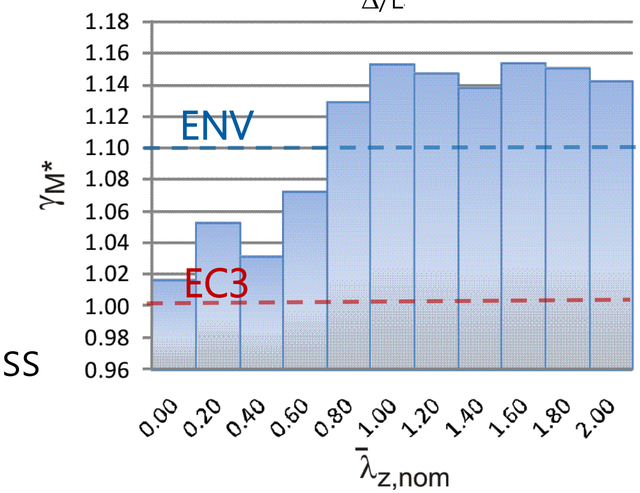
„Bias“ towards lower fractiles of resistances already included in population considered for γ_M-calculation

INITIAL (RE-)ASSESSMENT OF γ_{Mi} FOR EC3 REVISIONS

- Assessment based on literature studies and tolerances indicated values of γ_{M1}>1,0







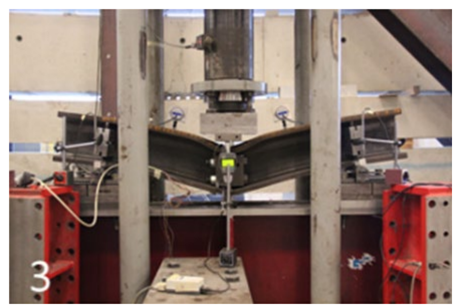
- It was originally planned to „relax" column straightness tolerances
- → Some countries chose higher γ_{M1}=1,1 due to insufficient database and lack of investigations

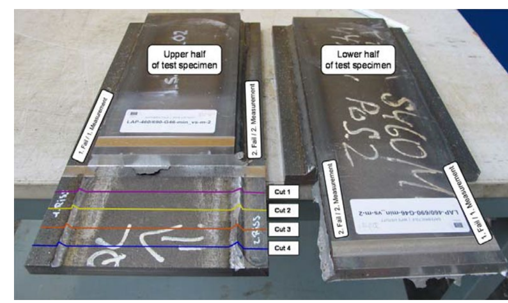
- → CEN TC250/SC3 Ad-Hoc Group and EU-RFCS Project SAFEBRICTILE

RFCS-PROJECT "SAFEBRICTILE" (2013-2016)

❑ Adaptation of provisions in EN 1990 (reliability standard of the Eurocode series) to provide a dedicated, consistent evaluation procedure for γ_{Mi}-values

❑ Review of EC3 design rules for important limit states, from ductile to brittle:





❑ Compilation of a database of European steel product properties

❑ Assessment of the required γ_{Mi}-values, adaptation of rules where required

· U C ·

University of Stuttgart
Germany

TU/e Technische Universiteit Eindhoven University of Technology

ArcelorMittal

ECCS
CECM
EKS

EUROPEAN COMMISSION

Assessment of Required $\gamma_{M,i}$-Values in SAFEBRICTILE

Assumed distributions based on developed "European Database" –
itself based on data provided by steel producers to this and other RFCS projects

- Yield strength and tensile strength

Steel	$f_{y,nom}$	$f_{y,m}/f_{y,nom}$	c.o.v	$f_{u,nom}$	$f_{u,m}/f_{u,nom}$	c.o.v
	MPa	-	-	MPa		
S235	235	1.25	5.5%	360	1.2	4.5%
S355	355	1.2	5%	470	1.125	3.25%
S460	460	1.15	4.5%	540	1.1	3.25%

- Geometrical properties

	Mean	c.o.v
b_m/b_{nom}	1	0.9%
h_m/h_{nom}	1	0.9%
t_{fm}/t_{fnom}	0.975	2.5%
t_{wm}/t_{wnom}	1	2.5%

- Modulus of elasticity

	Mean	c.o.v	Source
E_m/E_{nom}	1	5%	DNV

CONCLUSIONS FROM SAFEBRICTILE

- In SAFEBRICTILE, many design rules in EN1993-1-1:2006 were reviewed with respect to their required γ_M-values. Some necessary modifications to design rules were identified. These changes are already implemented in new EC3 (prEN1993-1-1:2020)
- Scatter bands for steel strength (f_y, f_u), geometry values of cross-sections and Young's Modulus E were needed; evidence from various sources and own tests was collected in an extensive database representing the current market. *These values are now declared (not imposed!) in Annex E of prEN1993-1-1:2020*
- The assessment of γ_{M0} and γ_{M1} showed that with statistical steel product properties in line with Annex E it is possible to *keep* γ_{M0} and γ_{M1} at 1,0 in the new EC3 and to have the same values in all NAs.
- γ_{M0} and γ_{M1} at 1,0 enables
  - to improve the ease of use, perhaps remove γ_{M0}
  - to have uniform calculation procedures all over Europe and in countries using EC3
- However: if steel properties cannot be assumed to be in line with Annex E, some of the values of γ_M might have to be increased by ~ 10%.
  → *"Meaning" of Annex E to be transferred to steel producing QM*

Content of prEN1993-1-1:2020 Annex E

Annex E
(informative)

Basis for the calibration of partial factors

E.1 Use of this informative annex

Informative Annex, not to be used by designers!

(1) This Annex provides additional information to that given in 8.1 on the basis for the calibration of the partial factors γ_{Mi} for buildings. The information in this Annex is not meant for direct use in design.

NOTE The way in which this Informative Annex is to be used can be set in the National Annex for use in a country.

E.2 Calibration

This leads to the mentioned $P_{non\text{-}exc.}$ ~10^{-3} for resistance values

(1) The values of the partial factors for buildings in 8.1 are calibrated considering a reliability index taken equal to 3,8, for a reference period of 50 years for variable actions and material properties and a resistance-side weighting factor of α_R=0,8.

(2) The design values of resistances R_d in EN 1993-1-1 are defined as the ratio between the nominal resistance and the partial factor γ_{Mi}. The nominal resistance is evaluated by using nominal values for all basic variables, see Formula E.1.

$$R_d = \frac{R_k}{\gamma_{Mi}} = \frac{R(\underline{X}_n)}{\gamma_{Mi}}$$

(Design resistances in EC3 are calculated by dividing the nominal resistance by factors γ_{Mi})

CONTENT OF PREN1993-1-1:2020 ANNEX E

Declaration of adopted statistical procedure from EN 1990

(3) EN 1990 Annex D - "Design assisted by testing" is applied for the calibration of the partial factors γ_{Mi} for buildings. The assumed scatter bands (mean values, coefficients of variation) for material properties and dimensional parameters are given in Table E.1 and Table E.2 respectively. For dimensional parameters not specifically mentioned in Table E.2, it is assumed that the mean values are equal to the nominal values and the standard deviations are equal to half of the interval between the nominal value and the lower bound of the applicable tolerance interval in EN 1090-2 or other relevant product standards.

(4) Scatter bands of parameter values X from production may generally be assumed to be in line with the assumptions made for the calibration of γ_{Mi} values for buildings, if the characteristic value X_k and the design value X_d determined from the production statistics both match or exceed the corresponding reference values $X_{5\%}$ and $X_{0,12\%}$ in Table E.1 and Table E.2. The values X_k and X_d for the production statistics may be determined by the procedures given in EN 1990 Annex D. They refer to non-exceedance probabilities of 5% and 0,12% respectively.

NOTE The values in Tables E.1 and E.2 represent the materials and products currently available on the European market satisfying the relevant European product standards.

Explanation of the verification of compliance with the assumptions

CONTENT OF PREN1993-1-1:2020 ANNEX E

Table E.1 — Assumed variability of material properties

Parameter	Steel grade	Mean value X_m	Coefficient of variation	Upper reference value $X_{5\%}$	Lower reference value $X_{0,12\%}$
Yield strength, f_y	S235, S275	1,25 $R_{eH,min}$[a]	5,5%	1,14 $R_{eH,min}$[a]	1,06 $R_{eH,min}$[a]
	S355, S420	1,20 $R_{eH,min}$[a]	5,0%	1,11 $R_{eH,min}$[a]	1,03 $R_{eH,min}$[a]
	S460	1,15 $R_{eH,min}$[a]	4,5%	1,07 $R_{eH,min}$[a]	1,00 $R_{eH,min}$[a]
	Above S460	1,10 $R_{eH,min}$[a]	3,5%	1,04 $R_{eH,min}$[a]	1,00 $R_{eH,min}$[a]
Ultimate tensile strength, f_u	S235, S275	1,20 $R_{m,min}$[a]	5,0%	1,11 $R_{m,min}$[a]	1,03 $R_{m,min}$[a]
	S355, S420	1,15 $R_{m,min}$[a]	4,0%	1,08 $R_{m,min}$[a]	1,02 $R_{m,min}$[a]
	S460 and above	1,10 $R_{m,min}$[a]	3,5%	1,04 $R_{m,min}$[a]	1,00 $R_{m,min}$[a]
Modulus of elasticity, E	All steel grades	210000 N/mm²	3,0%	200000 N/mm²	192000 N/mm²

[a] $R_{eH,min}$ and $R_{m,min}$ are the minimum yield strength R_{eH} and the lower bound of the ultimate tensile strength R_m, according to the applicable product standard, e.g. of the EN 10025 series.

values very similar to assumptions in SAFEBRICTILE (just slightly adapted)

two columns to be used for compliance verification (see slide 13)

CONTENT OF PREN1993-1-1:2020 ANNEX E

Table E.2 — Assumed variability of dimensional parameters

Dimension type	Parameter	Mean value X_m	Coefficient of variation	Upper reference value $X_{5\%}$	Lower reference value $X_{0,12\%}$
Outer dimensions of cross-section	Depth h	1,0 h_{nom} [a]	0,9%	0,98 h_{nom} [a]	0,97 h_{nom} [a]
	Width b	1,0 b_{nom} [a]	0,9%	0,98 b_{nom} [a]	0,97 b_{nom} [a]
	Outer diameter d of circular hollow section	1,0 d_{nom} [a]	0,5%	0,99 d_{nom} [a]	0,98 d_{nom} [a]
Plate thickness	I- and H-sections: flange thickness, t_f	0,98 $t_{f,nom}$ [a]	2,5%	0,95 $t_{f,nom}$ [a]	0,91 $t_{f,nom}$ [a]
	I- and H-sections: web thickness, t_w	1,0 $t_{w,nom}$ [a]	2,5%	0,96 $t_{w,nom}$ [a]	0,93 $t_{w,nom}$ [a]
	fabricated hollow sections, thickness, t	0,99 t_{nom} [a]	2,5%	0,95 t_{nom} [a]	0,92 t_{nom} [a]
	cold-formed sections made from coils, t	0,99 t_{nom} [a]	2,5%	0,95 t_{nom} [a]	0,92 t_{nom} [a]
	heavy plates, thickness, t	0,99 t_{nom} [a]	2,5%	0,95 t_{nom} [a]	0,92 t_{nom} [a]

[a] nominal dimensions according to the applicable product standard or specification.

OBJECTIVE OF THE NEW TC459/TC250-SC3 WG

*Development of a **CEN Technical Specification***

CEN/TC 459/SC 3

Date: 2021-01

prCEN/TS 10WG 9:2020

Secretariat: DIN

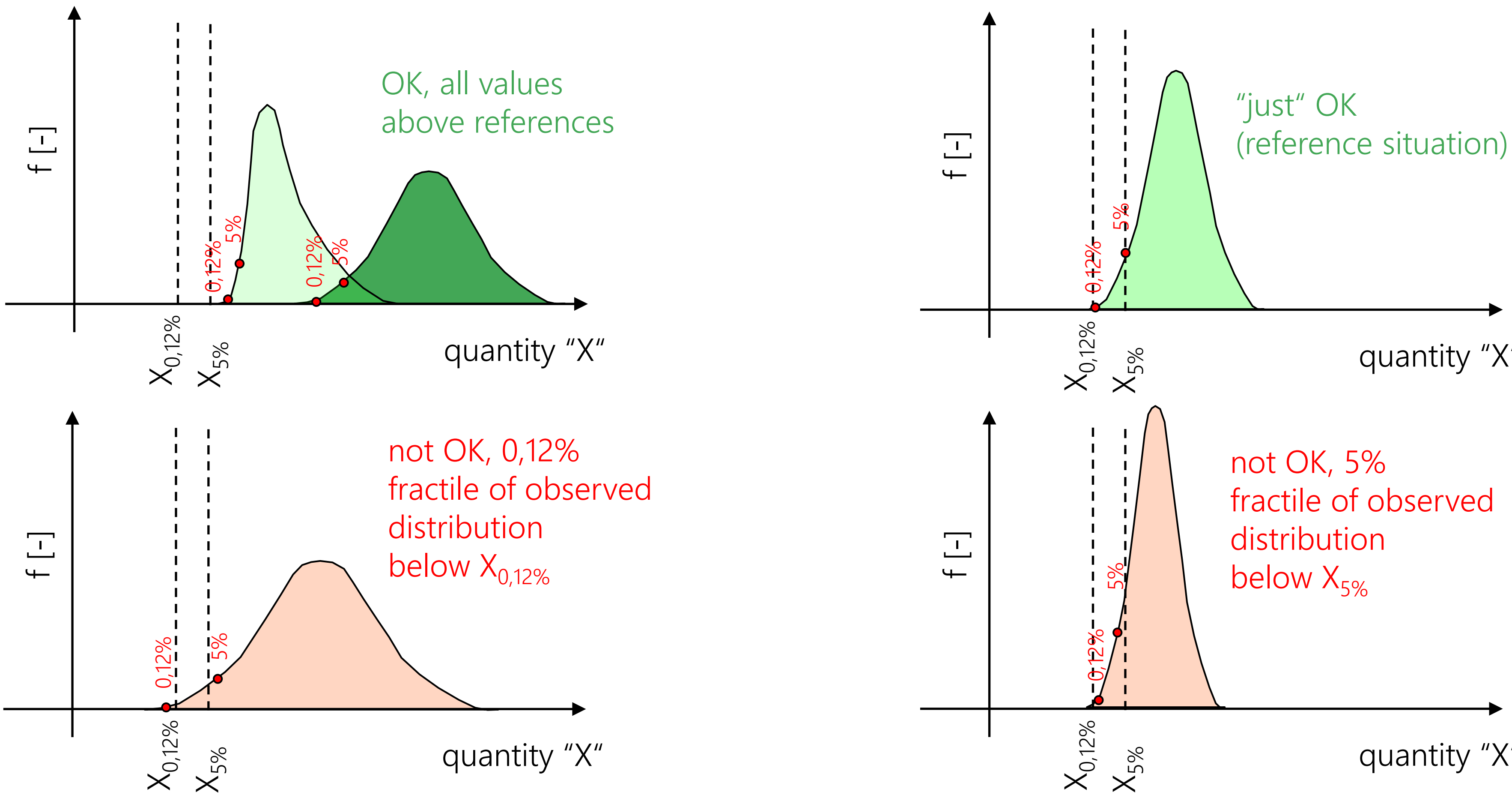
CEN/TC 459/SC 3/WG 9 N 21

Statistical verification of partial factors for buildings according to Eurocode 1993-1-1 Annex E

- ❑ Members of TC459/SC3 (→ EN10025) and TC250/SC3 present and solutions are sought to ensure "compatibility" between the assumptions in Annex E and production
- ❑ The main envisioned content should be procedures for demonstrating equivalence to the assumptions presented in Annex E– multiple solutions are currently being considered

Proof of "Direct Compliance" with Annex E (simplest case)

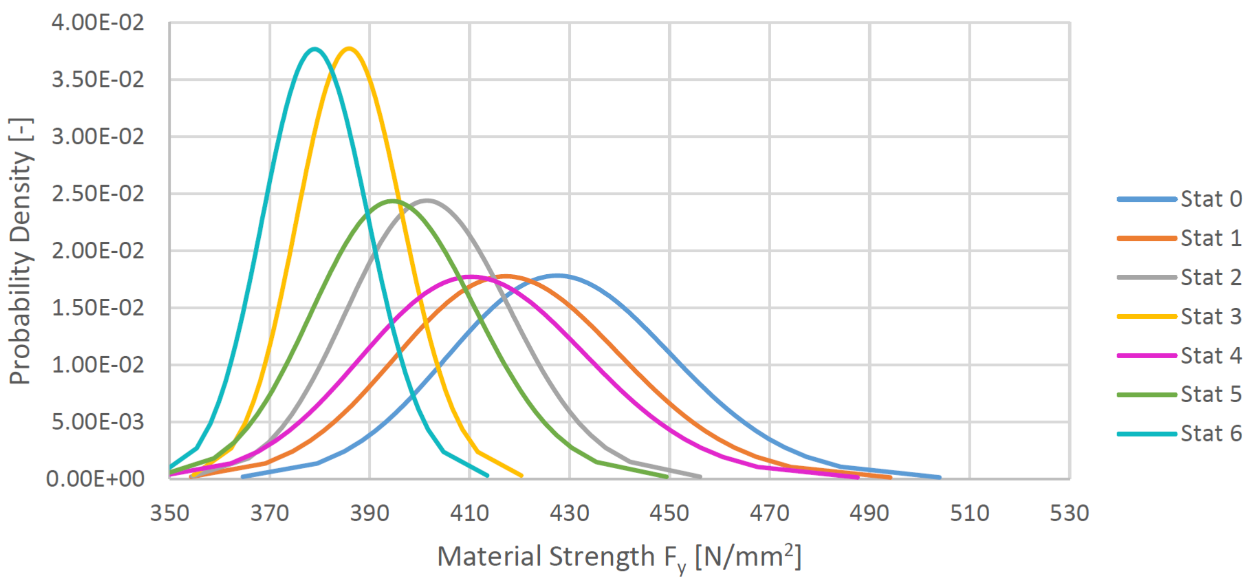
- Upper and lower reference values are given in Tables
- They serve as "anchor points" for statistical distributions



Strength // Geometry Parameter Combinations

Question: *is it possible to obtain "the same" values of γ_M with other combinations of scatter bands for strength and geometry than the ones used in prEN1993-1-1 – Ann. E?*

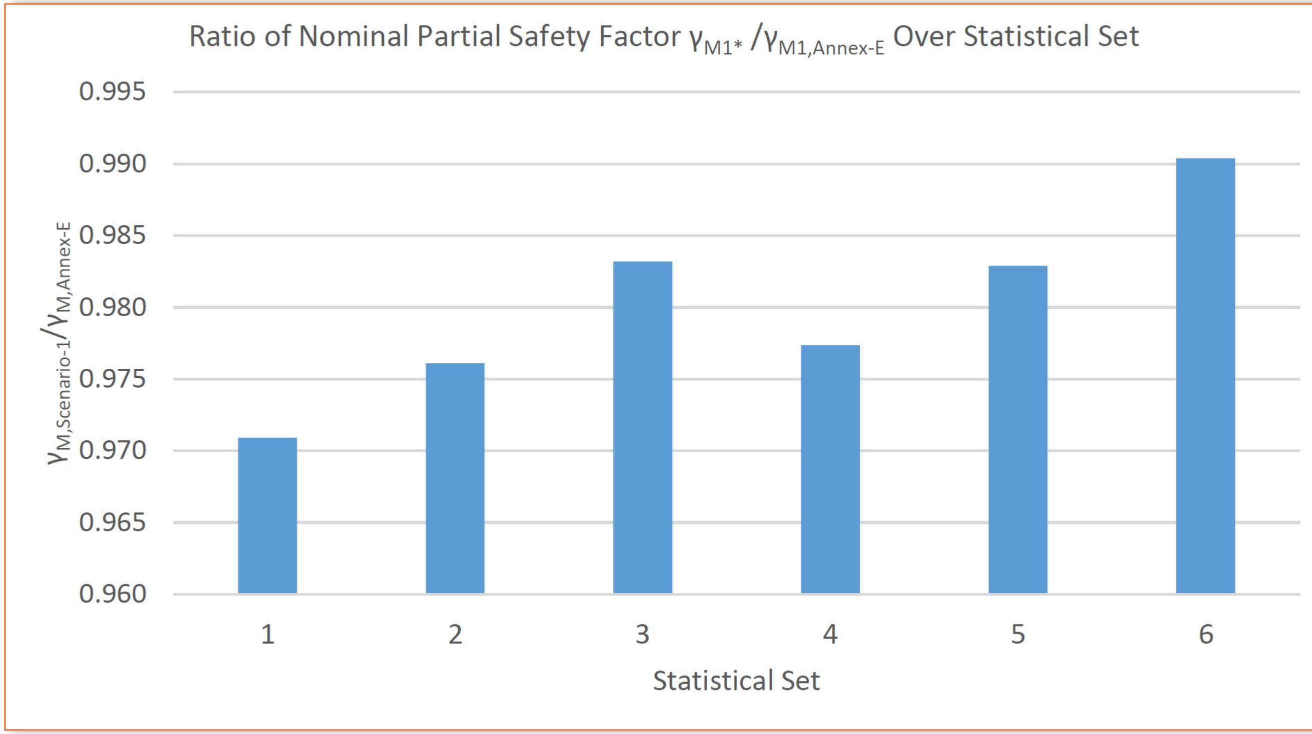
- One simple example considered here: Buckling of a "welded HEB340" (equivalent geometry) in S355 about the weak axis, relative slenderness $\bar{\lambda}_z$=1.0
- Scatter bands of f_y were varied, section height and width could scatter as in Annex E, but plate thicknesses were taken as deterministic values (all values equal to nominal value!)



"Stat 0" = Annex E

STRENGTH // GEOMETRY PARAMETER COMBINATIONS

Results: relative difference between the resulting γ_M values for the distribution of Annex E and the other assumed sets of statistical distributions for f_y



→ general feasibility of alternative "matrix" demonstrated: other statistics for f_y can work if e.g. the geometry statistics are also different

However, the actual values to write are still open; e.g., the considered case does not include other geometric features that may matter (outer dimensions, relative dimensions, …)

STRUCTURAL RELIABILITY - THE PRACTICE AND BACKGROUND OF EC3 RULES FOR STEEL STRUCTURES

THANK YOU!

PRESENTATION DURING THE JCSS MEETING

DECEMBER 8TH, 2021

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