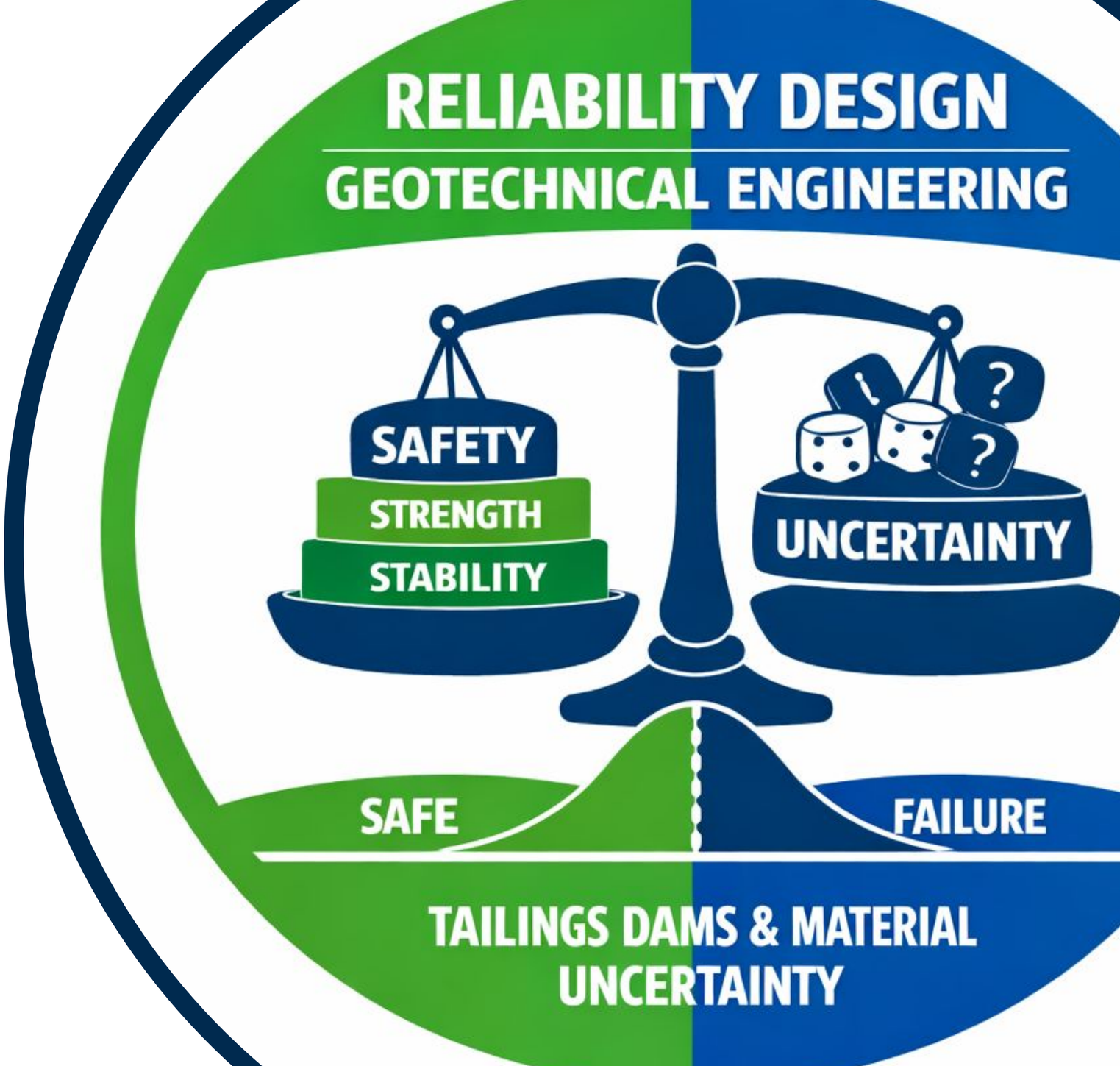
Klohn Crippen Berger

RELIABLE DESIGN WITH LIMITED DATA: CHARACTERISTIC STRENGTH SELECTION FOR SLOPE STABILITY ASSESSMENT

H.A Brandon, L. Kirstein, R. Duque, P. Delport, T. Jibiki and A. Fourie



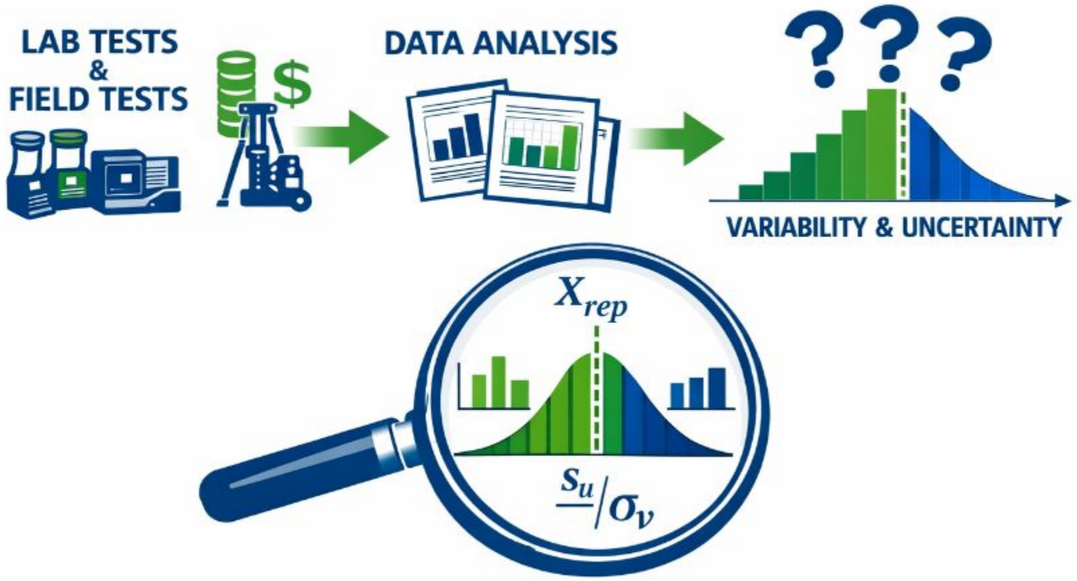
SELECTION OF REPRESENTATIVE VALUES

How can we define the strength parameter for a foundation material of a TSF based on limited data while accounting for uncertainties?

What does this mean for limit state assessment?

SELECTION OF REPRESENTATIVE VALUES

- Representative values
- Spatial and natural variability
- Limited data **$$$**
- Influence on limit state design
- Safety and financial implications
- Laboratory and field tests



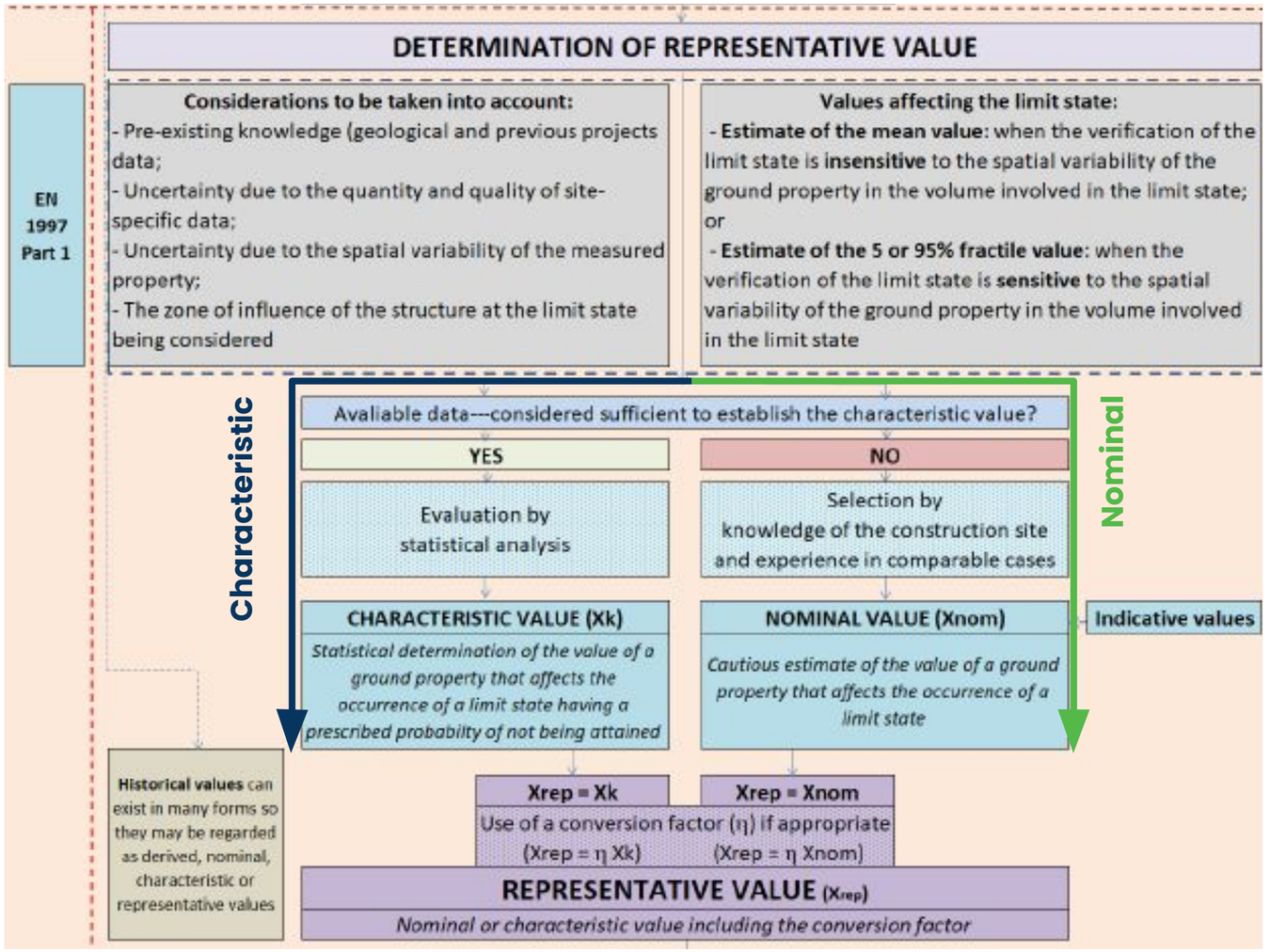
SELECTION OF REPRESENTATIVE VALUES

- Engineering judgment and the selection of nominal values
- Implicitly consideration of variability
- How can we explicitly account fo uncertainties?
- Eurocode 7 2nd Generation – a data-driven approach

EUROCODE 7

2ND GEN

- Eurocode 7 2nd Generation
- Reliability-design approach
- Representative value selection
- Desktop studies
- **Characteristic** and **Nominal** values from derived values



INFLUENCE OF SPATIAL VARIABILITY

- Scale of fluctuation (θ) and zone of influence (L)
- Typical values:
  - 1.35 m for vertical θ
  - 20/30 m for horizontal θ

Type	Definition	L v θ	Representative value	
			Value	Estimate of
A	"If the limit state is insensitive to spatial variability of the ground, the representative value of the ground property shall be determined as an average value."	L >> θ	Nominal (cautious) or Characteristic (statistical)	Average value Mean value
B	"If the limit state is sensitive to spatial variability of the ground, the representative value of the ground property shall be determined as an inferior or superior value."	L < θ	Nominal (cautious) or Characteristic (statistical)	Inferior (unfavourable) or superior (favourable) value 5% (unfavourable) or 95% (favourable) fractile
C	If the limit state is sensitive to the spatial variability of the ground, but not to the extent corresponding to the bounds given by the average and the inferior or superior values. The representative value is between the average/mean and the inferior or superior value. Type C is an intermediate case type between types A and B.	L > θ	Nominal (cautious) or Characteristic (statistical)	Average value and inferior (unfavourable) or superior (favourable) value Mean value and 5% (unfavourable) or 95% (favourable) fractile

SELECTION OF CHARACTERISTIC VALUE

- Definition of the coefficient of variation – Known, unknow and literature

$$CoV = \frac{\sigma}{\mu}$$

$$X_k = X_{mean}[1 \pm k_n V_x]$$

Cases with different knowledge concerning Vx	Type of estimate of the characteristic value		
	A: Estimate of the mean value $\Gamma^2 = 0$	B: Estimate of the inferior (5%) or superior (95%) fractile value $\Gamma^2 = 1$	C: Estimate of the intermediate value $\Gamma^2 = \theta/L$
Case 1: (V_x known) and Case 3: (V_x assumed)	$N_{95}\sqrt{\frac{1}{n}}$	$N_{95}\sqrt{1+\frac{1}{n}}$	$N_{95}\sqrt{\Gamma^2+\frac{1}{n}}$
Case 2: (V_x unknown)	$t_{95,n-1}\sqrt{\frac{1}{n}}$	$t_{95,n-1}\sqrt{1+\frac{1}{n}}$	$t_{95,n-1}\sqrt{\Gamma^2+\frac{1}{n}}$

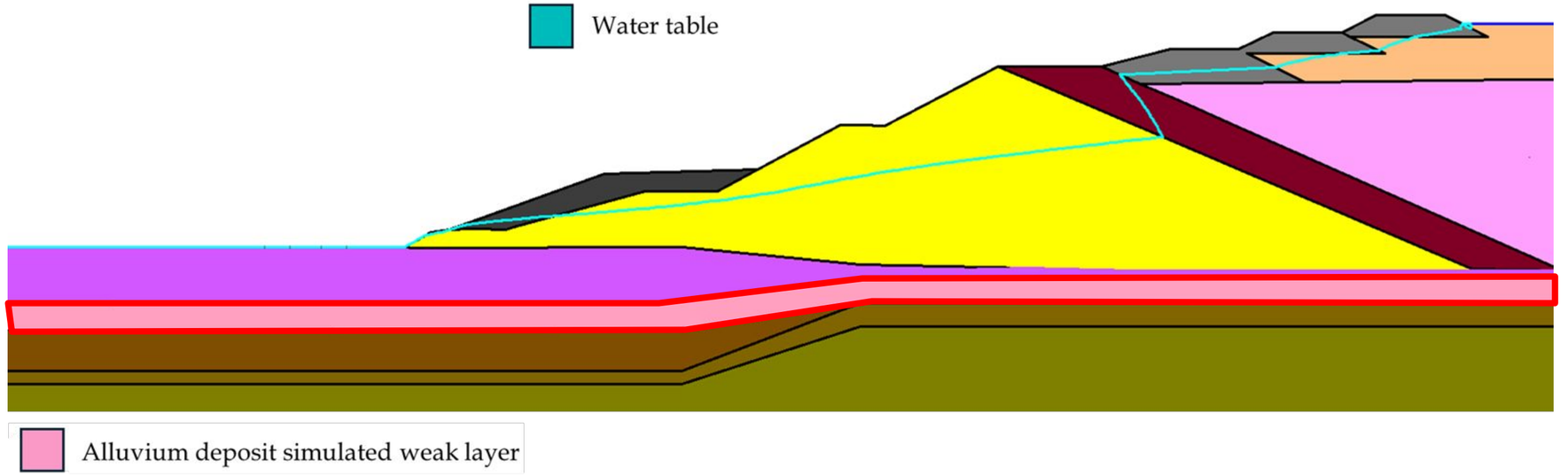
CASE STUDY

- Scenarios
- Alluvium layer
- 12 MSS

Table III

Case study scenarios

Scenario	Type	Design consideration	Representative value (X_{rep})
N	-	No consideration of the sample number or the influence of spatial variability	X_{nom} = sample mean
K2A	A	Spatial variability does not influence the limit state	X_k = mean value with 95% confidence level based on t-distribution
K2B	B	Spatial variability influences the limit state	X_k = 5% fractile based on t-distribution



CASE STUDY

- Summary statistics
- Characteristic values
- Representative values

Table V

Summary statistics for MSS tests

Number of tests (n)	X_{mean} (s_u/σ'_v)	Standard deviation (σ)	Coefficient of variation (%)
12	0.46 (0.40 – 0.53)	0.11	24%

Table VI

Input parameters used for deriving characteristic strength values

Scenario	Type	X_{mean}	k_n	V_x	Characteristic value (X_k)
K2A	A	0.46 (refer to Table IV)	0.51	24%	0.40
K2B	B	0.46 (refer to Table IV)	1.86	24%	0.25

Table VII

Case study scenarios: strength parameters

Scenario	Type	Design consideration	Representative value (X_{rep})
N	-	No consideration of the sample number or the influence of spatial variability	X_{nom} = 0.46
K2A	A	Spatial variability does not influence the limit state	X_k = 0.40
K2B	B	Spatial variability influences the limit state	X_k = 0.25

CASE STUDY

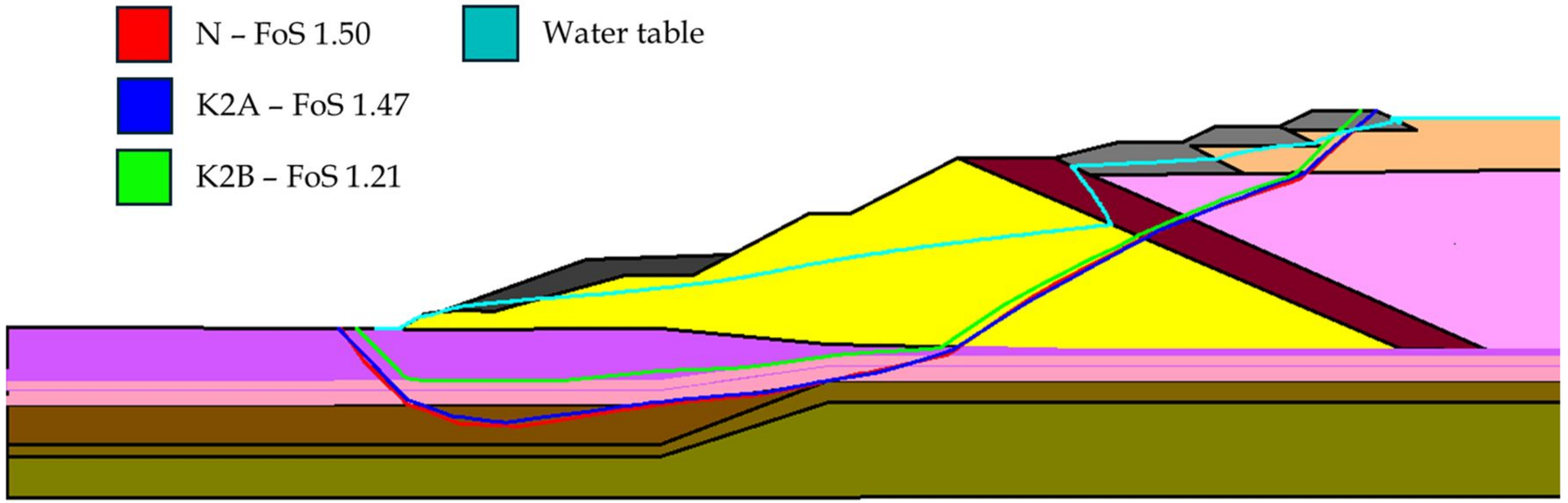
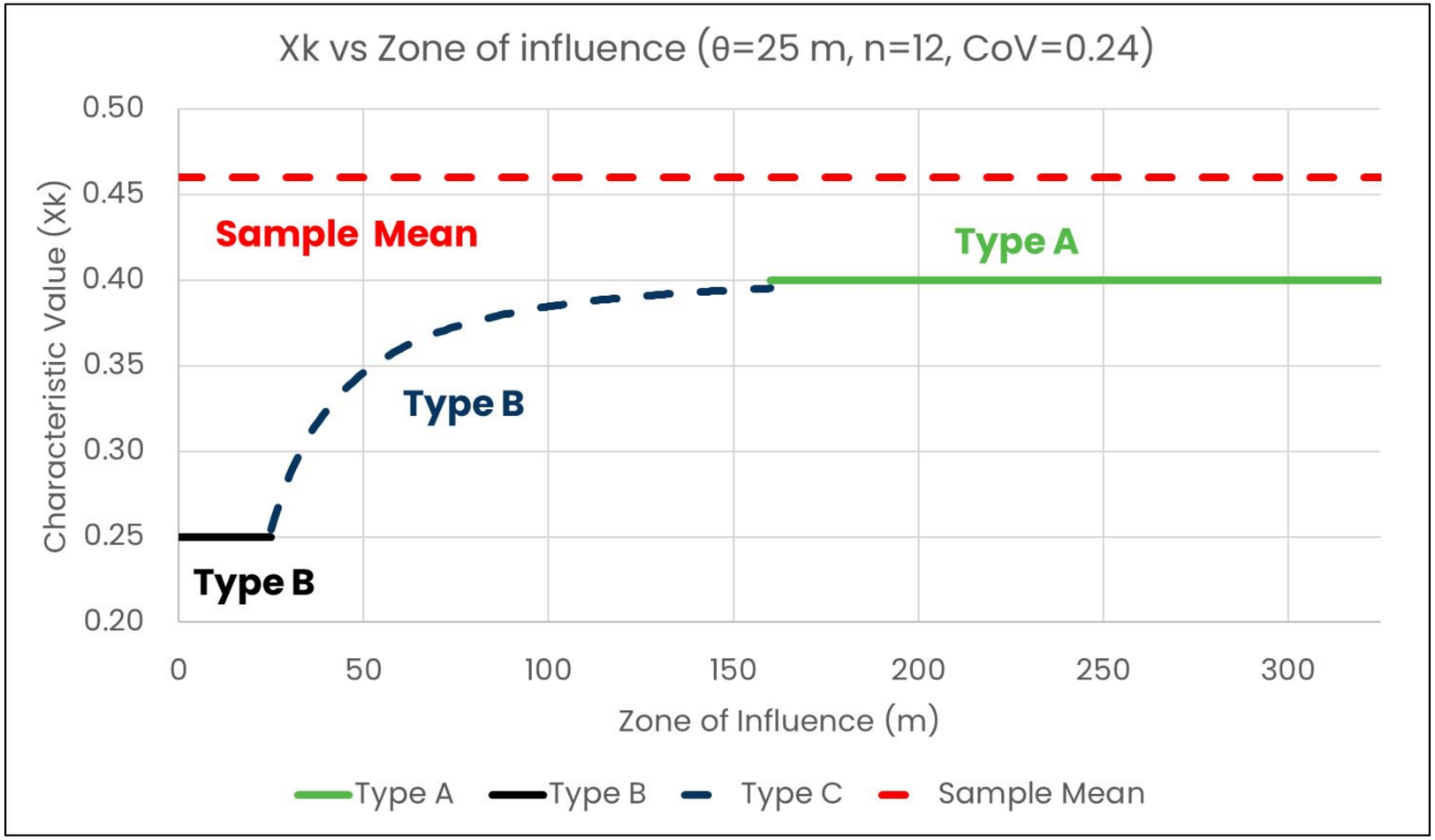


Table VIII
Case study scenarios results

Scenario	Type	Design consideration	s_u/σ'_v – characteristic value (X_k)	FoS
N	-	No consideration of spatial variability or sample size	0.46 – mean value	1.50
K2A	A	L >> θ	0.40 – mean value with 95% confidence level	1.47
K2B	B	L < θ	0.25 – 5% fractile	1.21

TYPE C CONSIDERATIONS



CONCLUSION

- Deterministic vs. Reliability-Based
- Uncertainty Explicitly Treated
- Representative Value Justification
- Eurocode 7 Strength
- Impact on TSF Stability
- Improved Transparency
- Essential for High-Consequence Facilities

All models are wrong, some are useful (Box, 1976)

Klohn Crippen Berger

THANK YOU!

Any questions?