WG 2: Exposures and Vulnerability

activity 4: exposure scenarios

probabilistic modeling

→ **human errors**

activity 5: structural behaviour

models and analysis

timber structures

ton vrouwenvelder

tno/tu-delft, the netherlands

Scheider/Matousek (500 cases)

Lack of knowledge	**25 %**
Careless engineering	**30 %**
Real error	**15 %**
Accepted risk	20 %

Imam/Chryssanthopoulos (156 failures bridges, steel)

design	**24 %**
limited knowledge	**23 %**
natural hazard	19 %
human error	**14 %**
accidents	13 %

Errors

Planning and design

- conceptual errors, including unforeseen mechanisms
- misinterpretations of rules
- calculating errors
- software errors
- drawing errors

Execution

- misreading of specifications
- bad workmanship
- inferior materials

Use

- operation
- inspection
- maintenance
- refurbishment.

Ellingwood / Distribution of errors over the building Process by Phase:

Reference	Planning and design	Construc tion	Utilization mainte-nance	Others	Total
CEB 157 (1983)	50[b]	40[c]	8	-	98
Matousek (1982)	45[d]	49	6	-	100
Talylor (1975)	36[e]	12[f]	-	-	-
Yamamoto and Ang (1982)	36	43	21	-	100
Rackwitz and Hillemeier (1983)	46	30	23	-	99
AEPIC	67	33	-	-	100
Melchers, et al. (1983)	55	24	21	-	100
Fraczek (1979)	55	53	-	-	108[g]
Allen (1979)	55	49	-	-	103[g]
Hadipriono (1985)	19	27	33	20	99
Hauser (1979)	37	35	5	23	100
Gonzales (1985)	29	59	-	13	101[g]

[a] Broken Includes cases where failure cannot be attributed clearly to any one factor

[b] Broken down as planning 25%; design 25%.

[c] Broken down as materials 15%; execution 25%.

[d] Broken down as planning 11%; design 34%.

[e] Identified as design, not planning.

[f] Does not differentiate between construction and utilization.

[g] Multiple erros for single failure.

On the average this leads to: design errors 40 %, construction errors 40% and utilization errors 20%.

$$Risk = p(H_i)\,p(D_j \mid H_i)\,p(S_k \mid D_j)\,C(S_k)$$

basic event

damage

collapse

Human error model

- Probability of making an error P(H)
- Magnitude of the error
- Effect on R: Δ ,e.g. zero mean, normal, sd $\sigma(\Delta)$

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$$P(F) = [1-P(H)]\, P(F|\text{no error}) + P(H)\, P(F \mid \text{error})$$

where $P(F|\text{ error}) = P(Z_e < 0) = P(R+\Delta - S < 0)$

Human error model

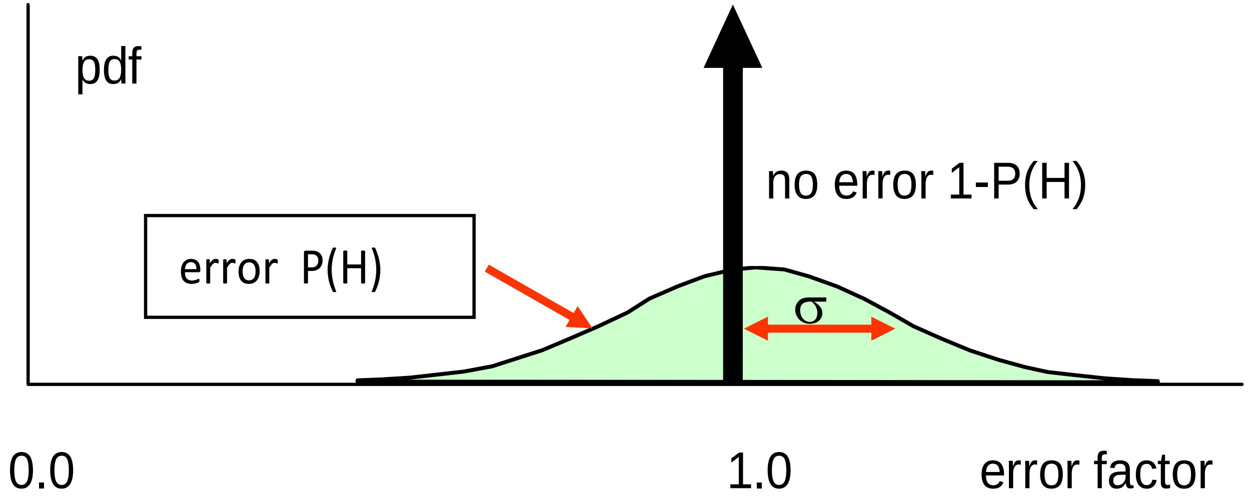


Figure 1: possible model for the effect of human error on resistance.

Numerical values

Aspects

- ✓ Professional skill / experience
- ✓ Complexity of the task, completeness or contradiction of information

- ✓ Physical and mental conditions, including stress and time pressure
- ✓ Adaptation of technology to human beings
- ✓ Social factors and organisation

In some handbooks [e.g. Gutman and Swain, 1983] general estimates for the probability of making errors are given.

Gutman/Swain

- Class 5 unbelievable
- Class 4 regular simple task, minimal stress
- Class 3 regular but more complex task, , some clues, less time
- Class 2 cues and memory necessary, distraction, little feed back
- Class 1 unfamiliar, complex, stress, no time

- **$P(error) \sim 10^{-class}$**

Example column design

- **Per design: 10-100 tasks**
  (load selection, structural mechanisms, equations, code interpretations, table look ups, computer input, calculations)
- **Per task P(HE) = 10^{-3}**
- **Per column design: P(H) = 0.03**
- **$V(\Delta) = \sigma(\Delta) / \mu(R) = 0.15$**

distribution over members [%]

	Ayyub	Yam
• Foundation	6	20
• Column and walls	11	30 (mostly walls)
• beams and trusses	11	30
• slabs and plates 34	10	
• Connections	9	
• others	33	10
Total	100	100

H	D|H	S|D	P	C	Risk
no error	column fails	structure fails			
	0,00012	1,00000	0,00012	10,0	0,00118
error	column ok				
0,03000	0,90000		0,02700	0,0	0,00000
	columns fails	structure ok			
	0,00802	0,90000	0,00022	1,0	0,00022
		structure fails			
		0,10000	0,00002	10,0	0,00024
			0,02736		0,00164
QA	gamma	robustness			

Period 50 a, P(H) = 0,04, $\sigma(\Delta)$= 0.15

$$Risk = p(H_i)\,p(D_j|H_i)\,p(S_k|D_j)\,C(S_k)$$

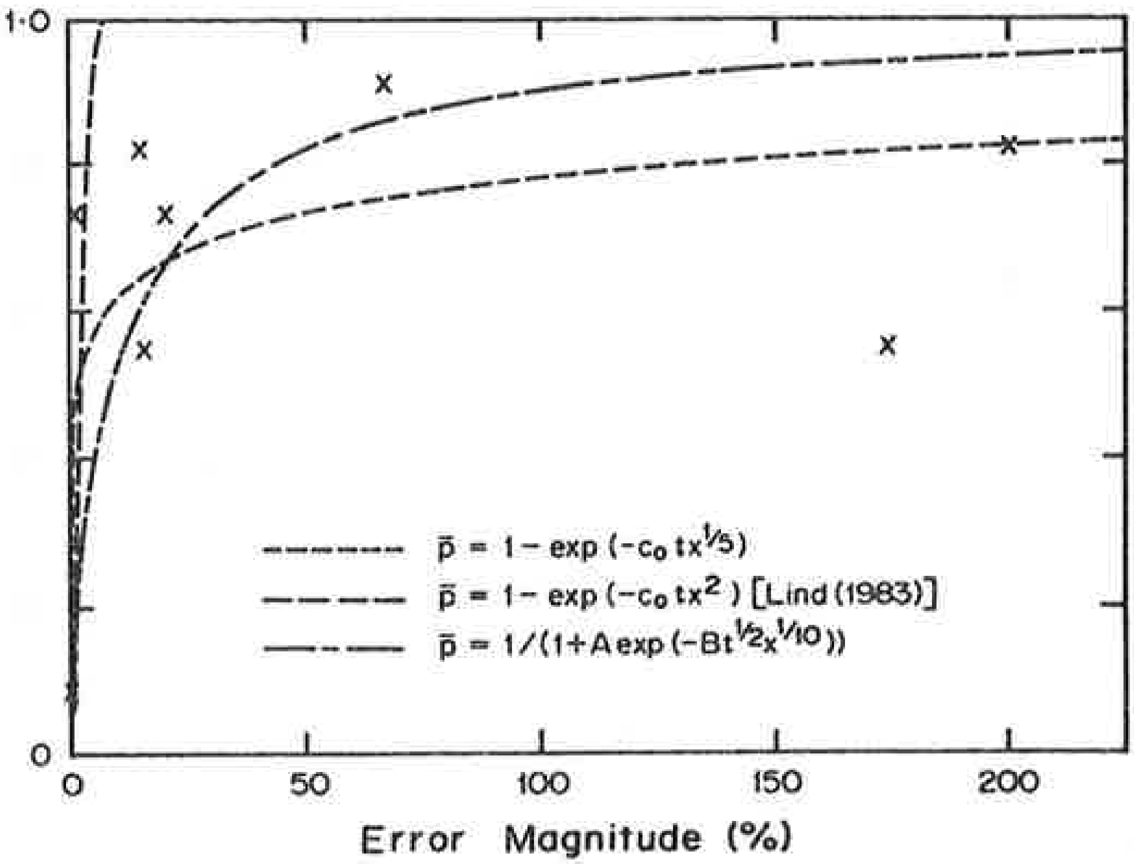
explosion
fire
human errror

removed column

collapse

	p(H) [50 year]	$P(D \mid H))$
explosion	$2x10^{-3}$	0.10
fire	$20x10^{-3}$	0.01
human error	$3x10^{-2}$	0.01

QA: Design checking



Checking Efficiency versus Error Magnitude at t = 20 minutes.

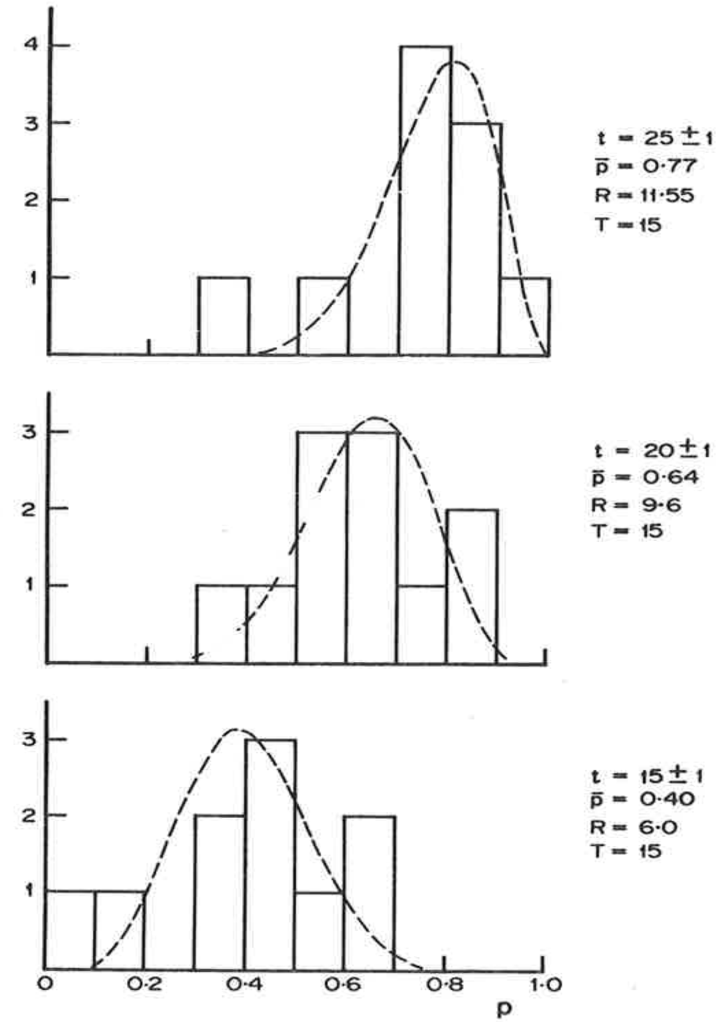
POD

Melchers / Stewart

1984

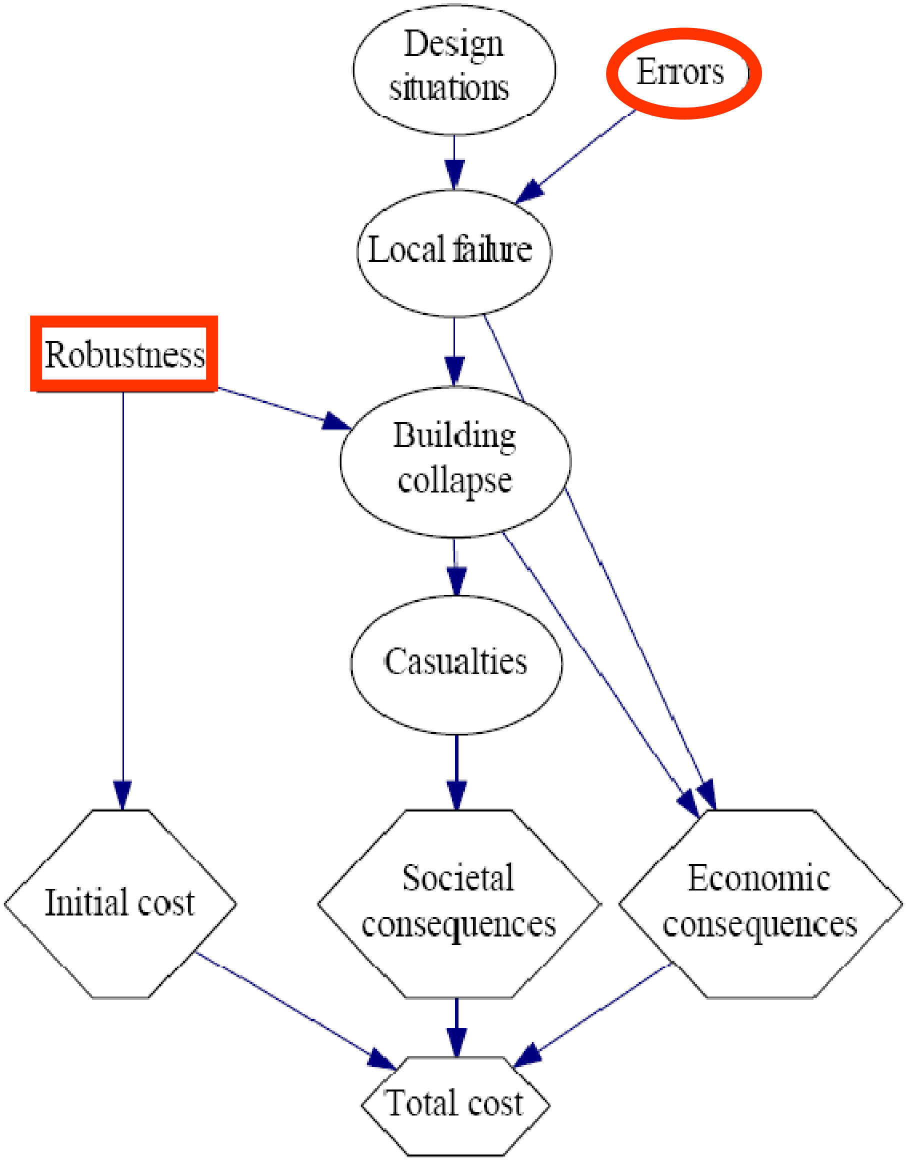
Time dependent

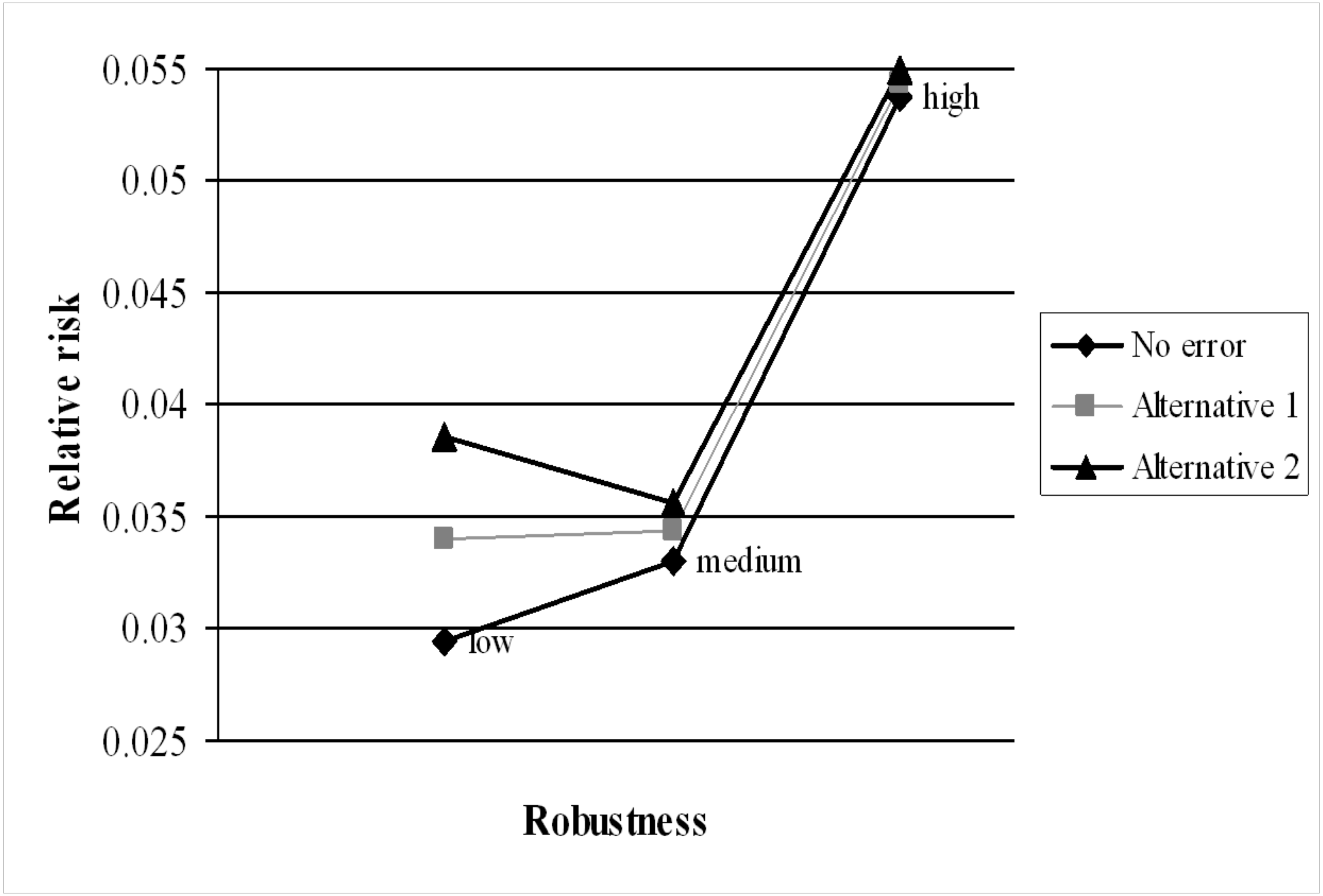
time dependency



Approach using Bayesian belief nets

(Holicky/Sykora)




0,055
0,05
0,045
0,04
0,035
0,03
0,025
Relative risk
Robustness
high
medium
low
No error
Alternative 1
Alternative 2

Human error / conclusions

- modelling is possible like other hazards
- Data is limited / numbers have to be estimated
- difficult points: correlation, experience
- optimization of QA is possible