COST Action TU 0601

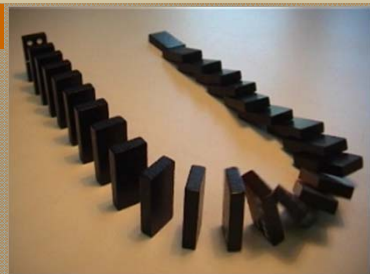
Robustness of structures

WG2

Modelling of exposures and vulnerability

ton vrouwenvelder

tu delft

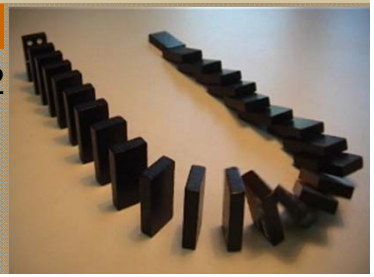


WG 2:

Exposures and Vulnerability

activity 4: exposure scenario models

activity 5: structural behaviour models



Step 1

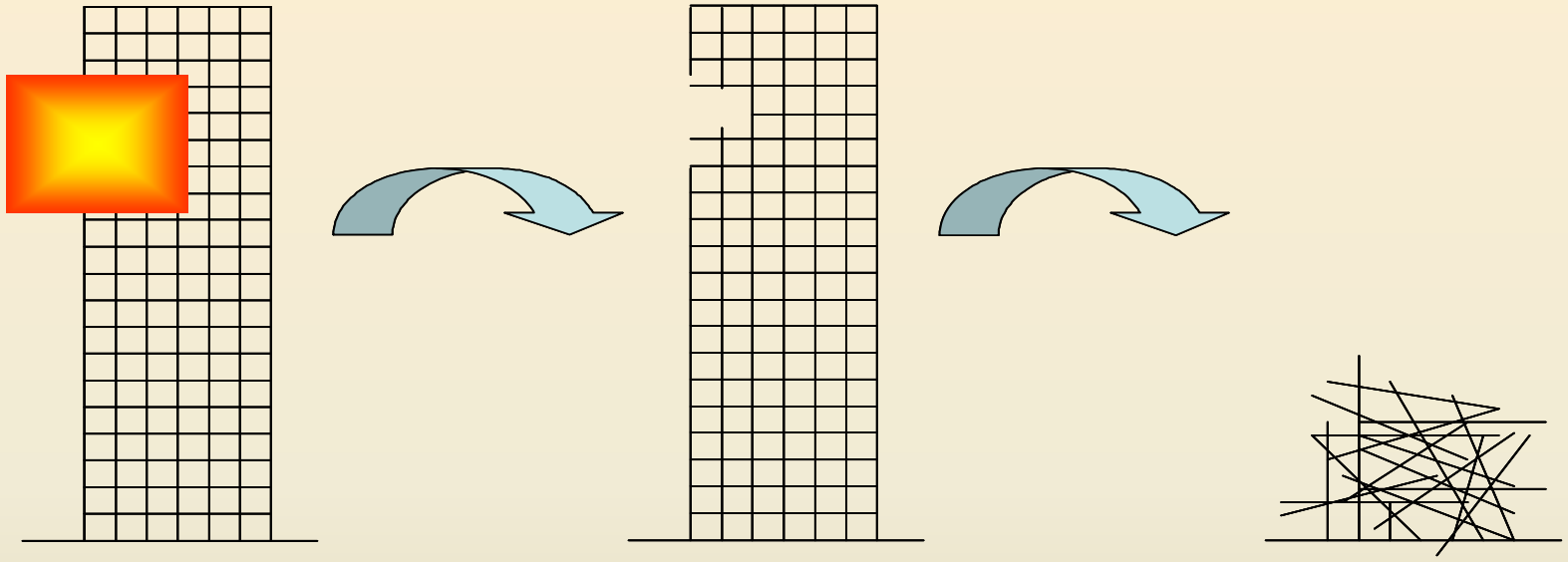
Identifical and modelling of relevant accidental hazards

Step 2

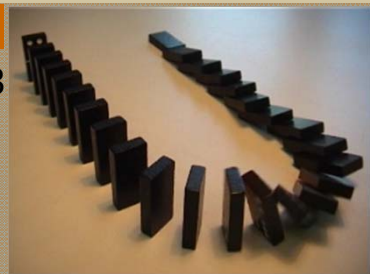
Assessment of damage states to structure from different hazards

Step 3

Assessment of the performance of the damaged structure



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



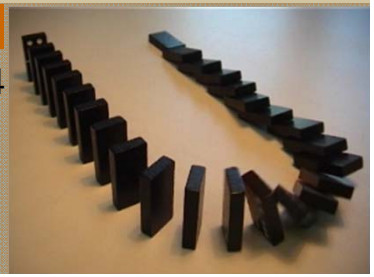
Factsheets Act 4 Hazard modelling

- Probabilistic modeling of exposure
- Explosion modelling
- Human error

} (P)

Factsheets Act 5 Structural behaviour: vulnerability and robustness

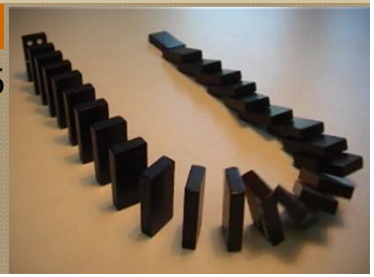
- Modelling and analysis (3P)
- Steel (2P)
- Concrete (P)
- Composite (P)
- Timber
- Existing structures



Activity 4: Exposure scenarios

Key words:

- **normal loads**
- **accidental loads**
- **human actions**
- **human errors**
- **unforeseeable actions**



Accidental paintings

Accidental paintings

Kamagurka

Accidental paintings

Kamagurka

Accidental paintings

Kamagurka

Activity 4: Exposure scenarios

Key words:

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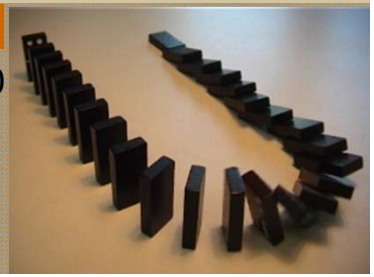
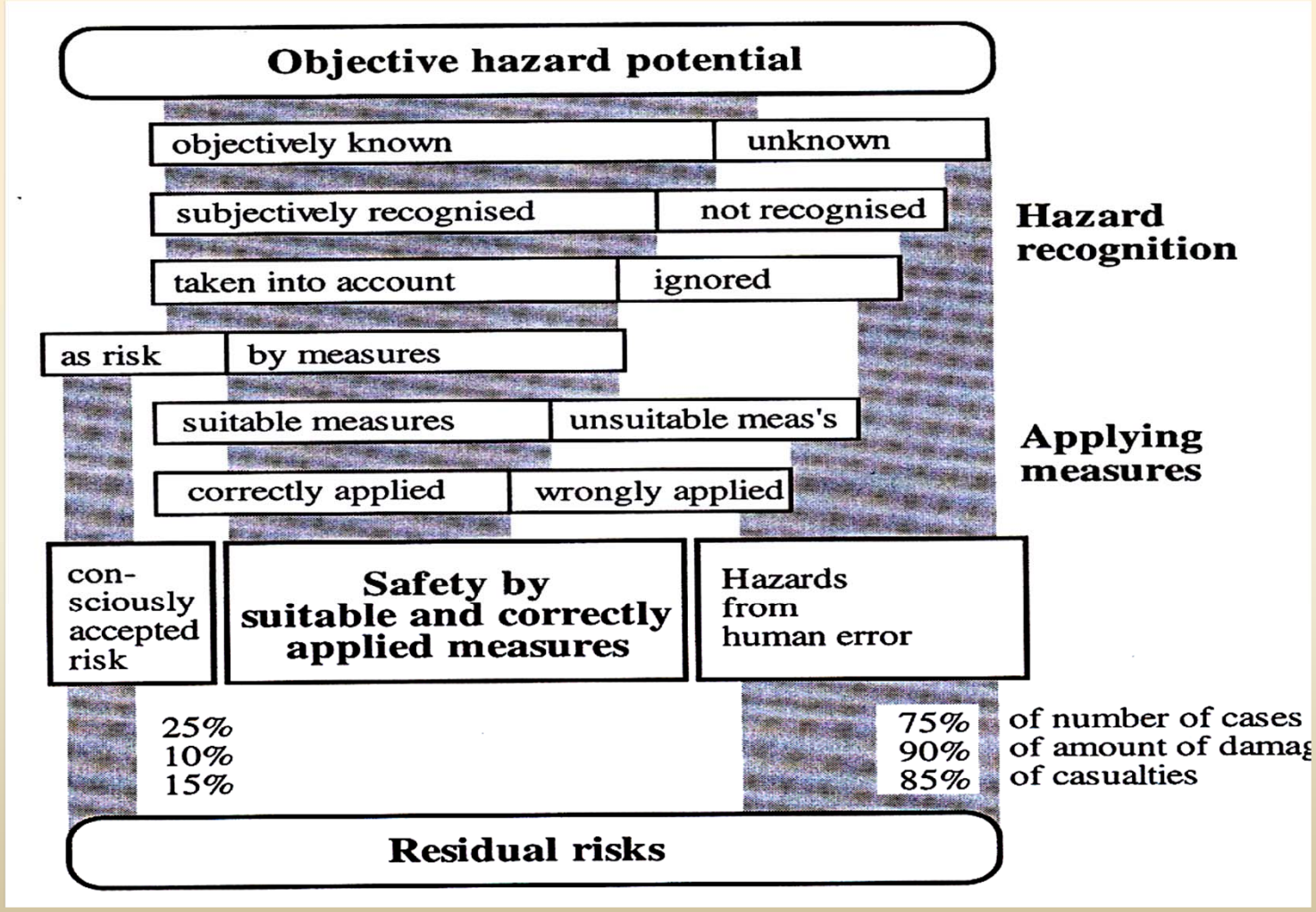
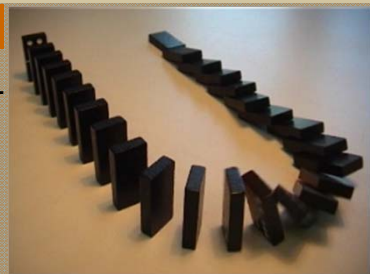


JCSS (Joerg Schneider)

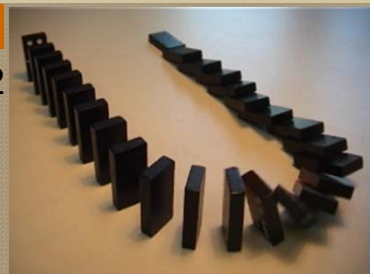




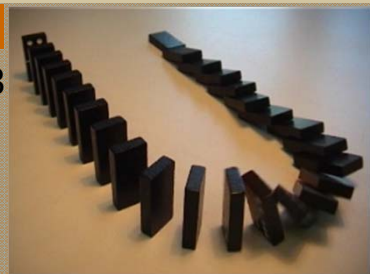
Unidentified conditions

- **objectively unknown (unforeseeable)**
- **in principle known, but difficult to recognize (unforeseen)**
- **known, but ignored for several reasons (not foreseen)**

Difficult to distinguish
All categories are a kind of human error
Still: what is the probability to the (effect) of the event?



- # DATA ??



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 %

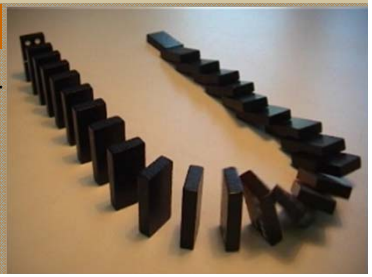
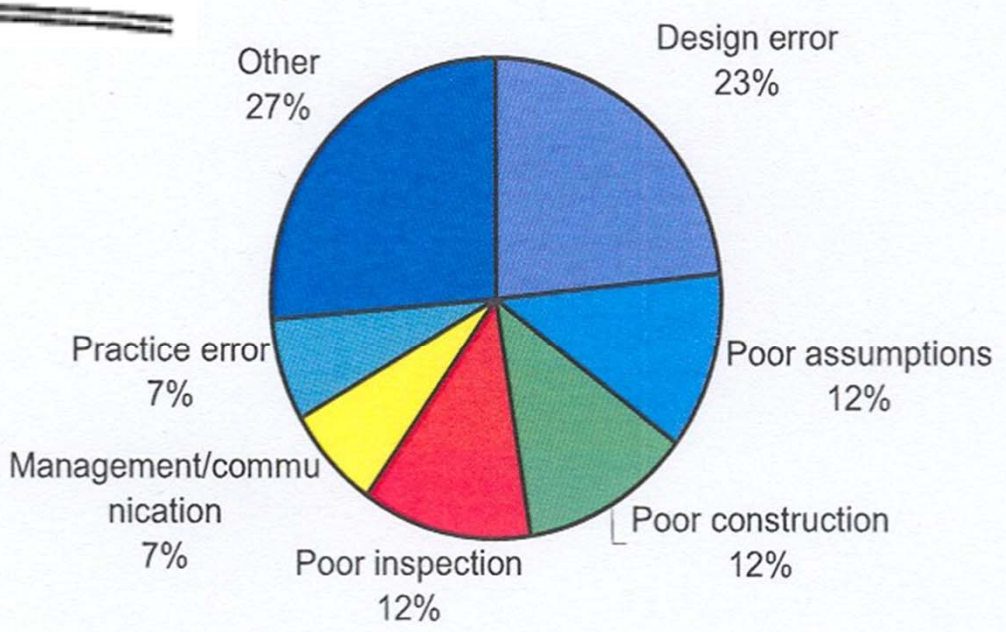


TABLE 8. Distribution of Failure Cases with Respect to Sources of Error by Participant

Description of the participant (1)	Failure cases (%) (2)
Project architect	3.0
Structural designer	48.2
Resident engineer	31.1
Inspector	27.6
Contractor (head office)	3.8
Contractor (site staff)	59.6
Contractor (workmen)	17.4
Operator (crane, vehicle, ship)	2.8



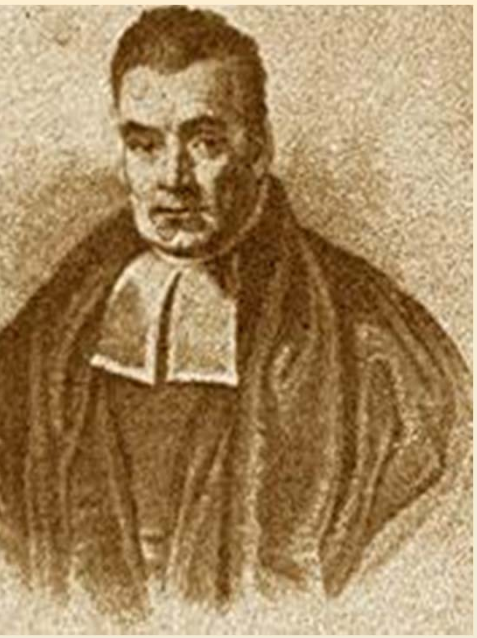
atistics The Netherlands (Ligtenberg, 1969)

fire	10^{-2} in 50 jaar
errors	**10^{-3}**
wind	10^{-3}
explosion	10^{-3}
impact	$3\ 10^{-4}$
overload	$3\ 10^{-4}$

(collapse factor 10 to 100 lower)

istribution 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



Thomas Bayes

the more data the better

but:

no data = no excuse.

Activity 5: Structural models

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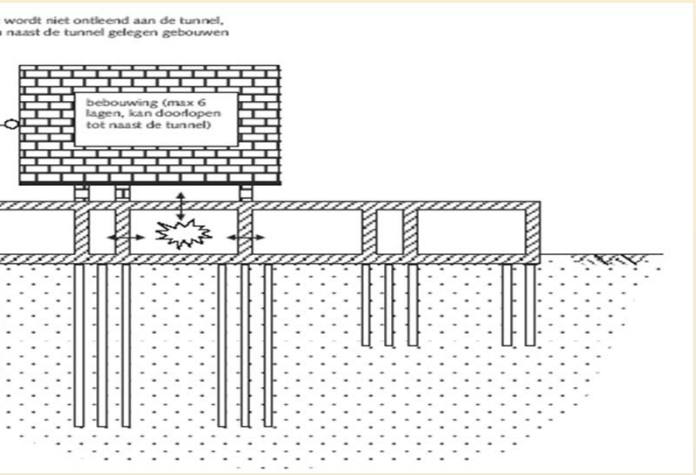
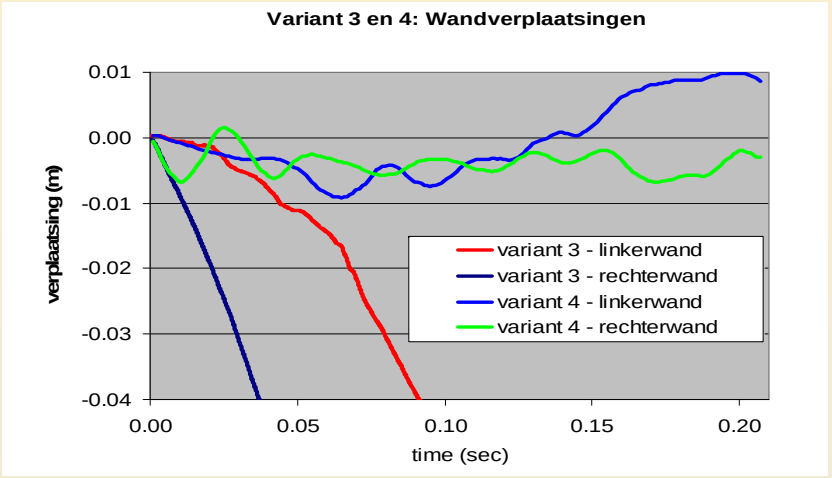
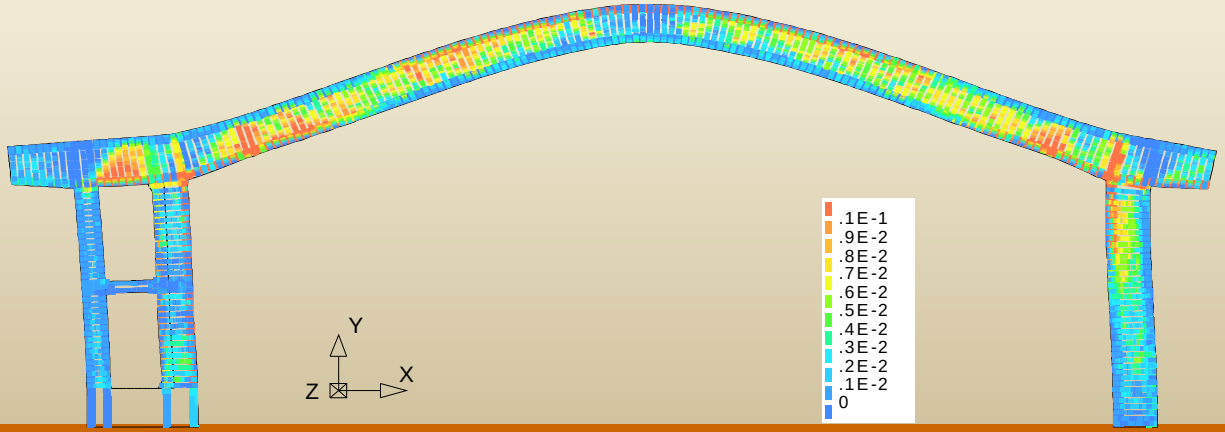




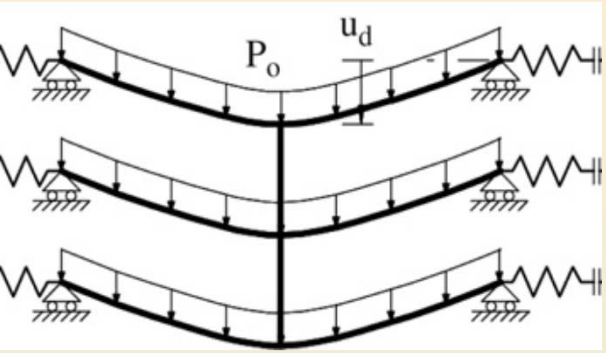


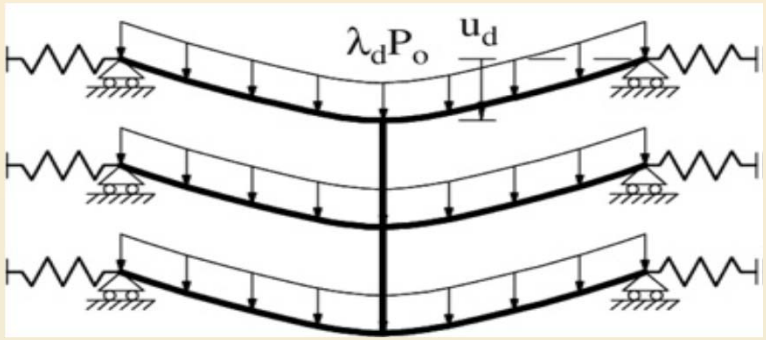
Fact sheet Modelling and analysis

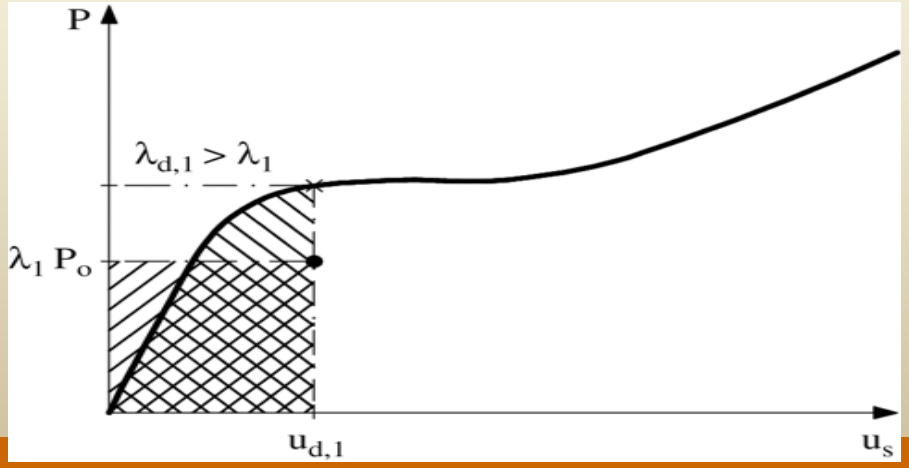
Key words:

- material, element, system behavior
- geometrical / physical nonlinear
- large deformations, catenary / arching actions,
- deformation capacity (joints),
- 2D-3D
- dynamic / static / simplified dynamic
- fem / applied element method

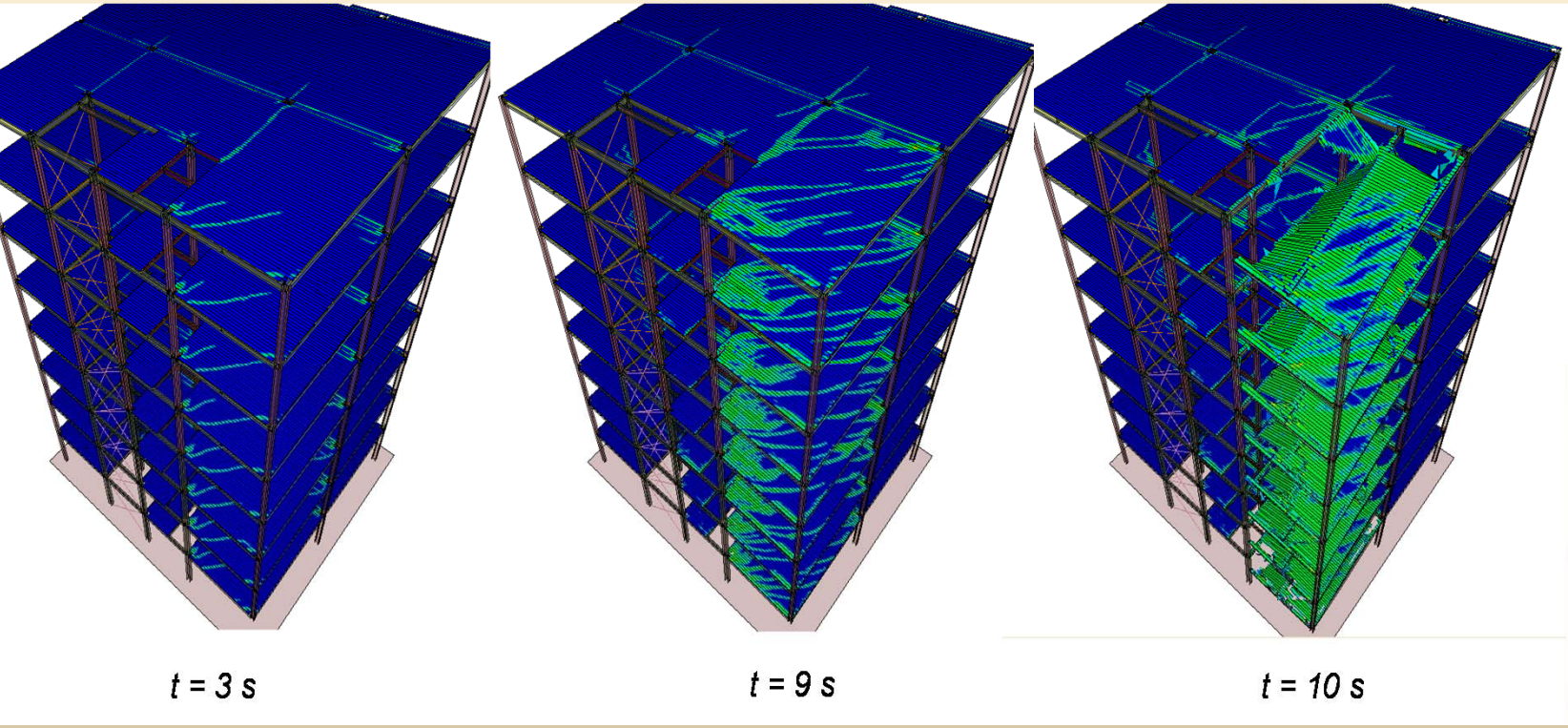
Nonlinear static response and simplified dynamic effects (Izzudin, 2008)



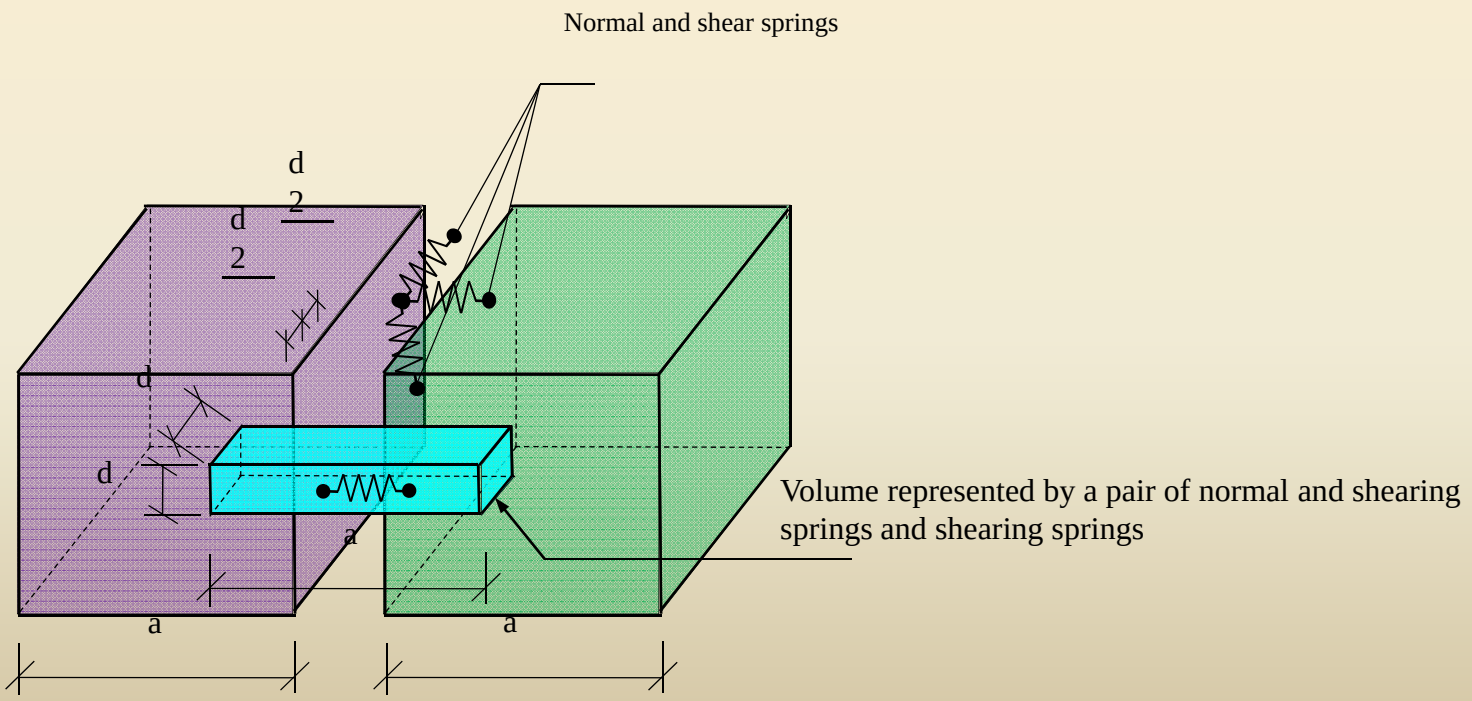




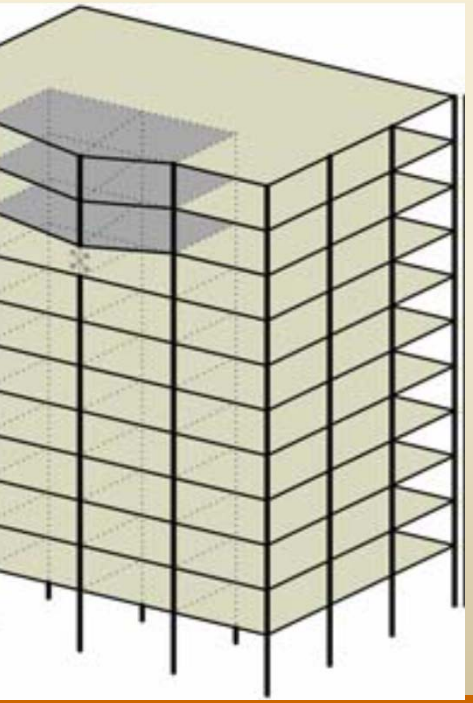
amic simulation for global FE models of a multistory building
asniewski, 2009)

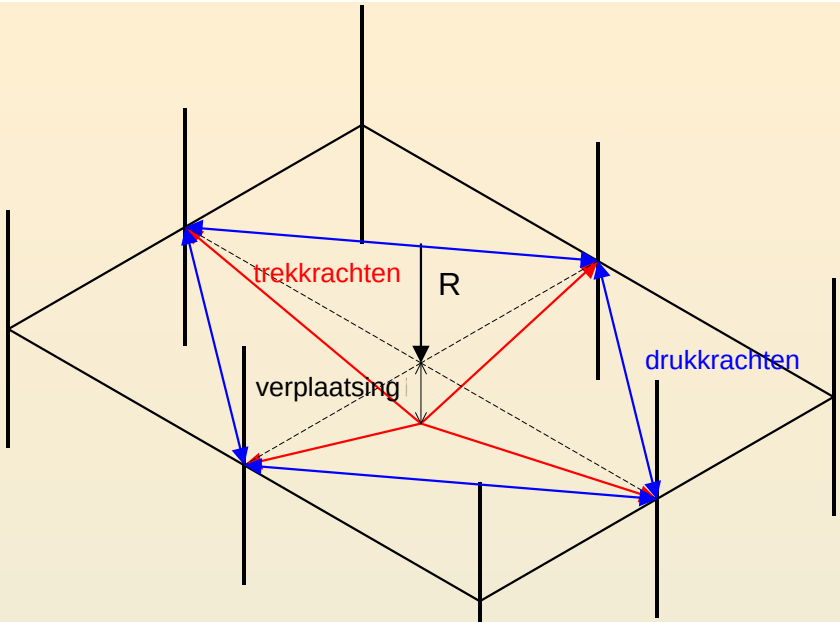


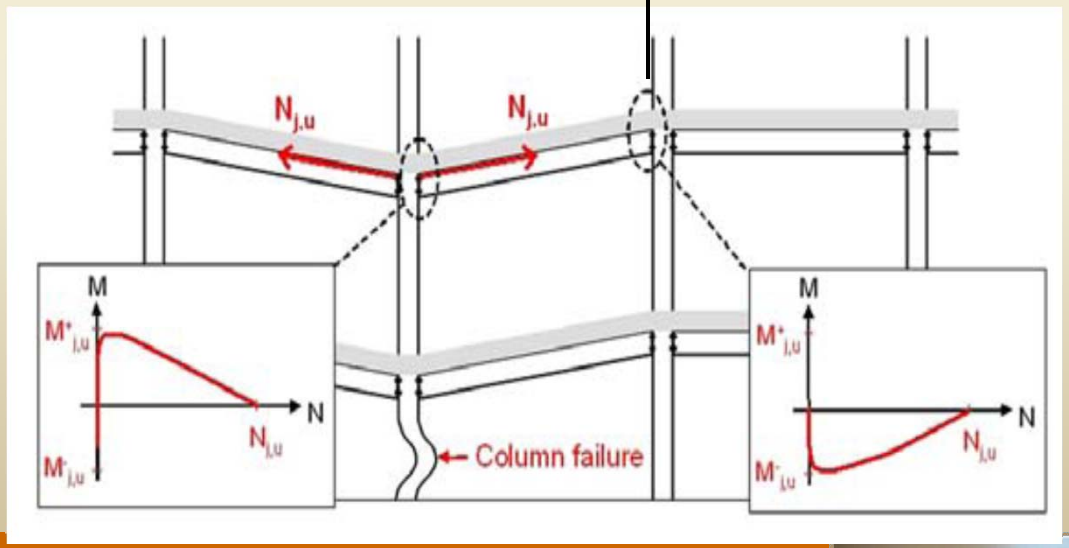
pplied Element Method



Removed column case





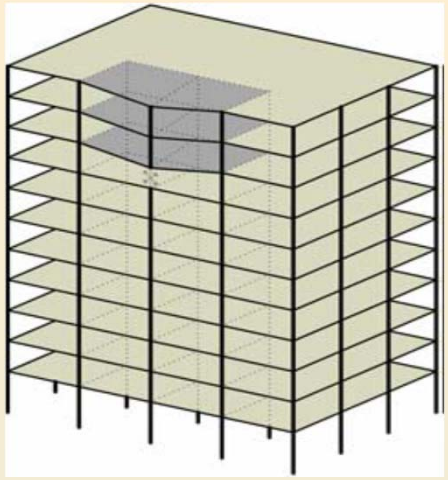


$$sk = p(H_i)\,p(D_j|H_i)\,p(S_k|D_j)\,C(S_k)$$

removed column

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

Demonstration of:



- deterministic model
- probabilistic model
- robustness measures
- cost effectiveness of measures