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

Risk based Robustness

Step 1

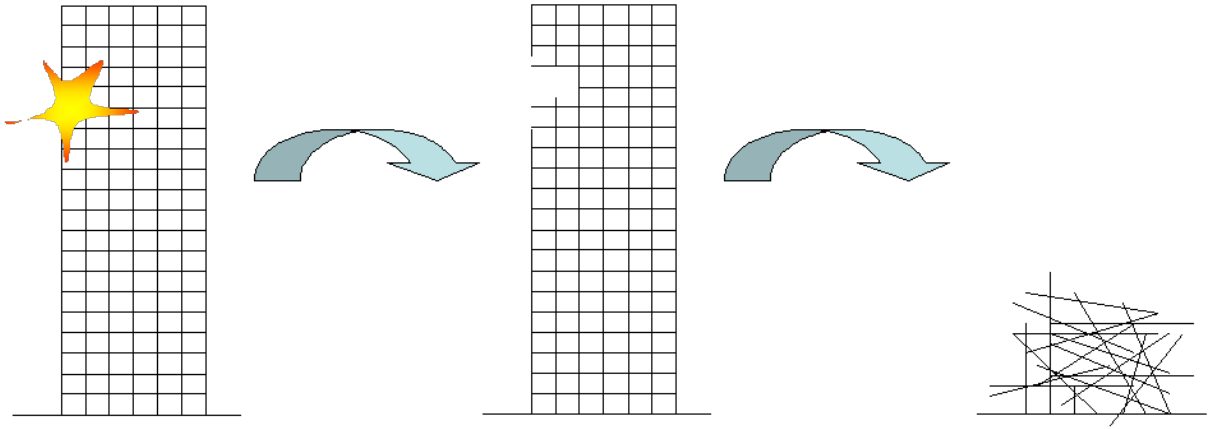
Identifical and modelling of relevant accidental hazards

Step 2

Assessment of damage states to structure from different hazards

Step 3

Assessment of the performance of the damaged structure



Assessment of the probability of occurence of different hazards with different intensities

Assessment of the probability of different states of damage and corresponding consequences for given hazards

Assessment of the probability of inadequate performance(s) of the damaged structure together with the corresponding consequence(s)

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

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

- hazard models

-member models

-post failure models

Model = physics + statistics

Overview of foreseeable actions.

Accidental /natural	**Accidental/manmade**	**Human influences**	**Normal loads (including the tail values)**	**Human Errors**
Earthquake	Internal explosion	Vandalism	self weight	Design error
Landslide	External explosion	Demonstrations	imposed loads	Material error
Tornado	Internal fire	Terrorist attack	car park loads	Construction error
Avalanche	External fire		traffic	Misuse
Rock fall	Impact by vehicle etc		snow	Lack of maintenance
High groundwater	Mining subsidence		wind	Miscommunication.
Flood	Environmental attack		hydraulic	
Volcano eruption				

JCSS Probabilistic Model Code

Part 1 **Basis of Design**
Part 2 **Modeling of loads**
Part 3 **Modeling of structural properties**

http://www.jcss.ethz.ch/
select “publications”
select “jcss model code”

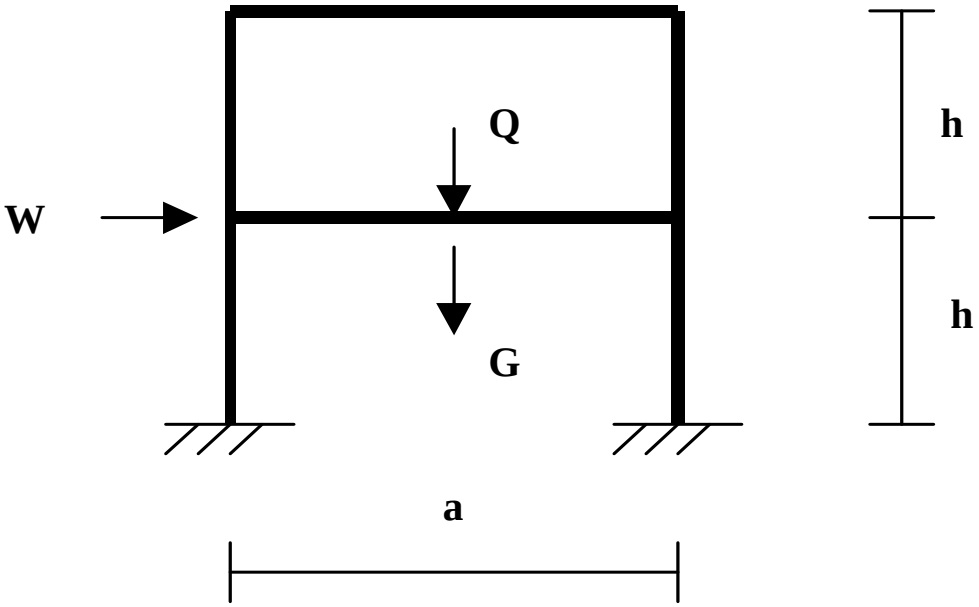
Part 2 Loads Models

2.0	General
2.1	Self weight
2.2	Live load
2.3	Industrial storage
2.4	Cranes
2.5	Traffic
2.6	Car parks
2.7	Silo load
2.8	Liquids/gasses
2.9	Temperature
2.10	Ground
2.11	Water/groundwater
2.12	Snow
2.13	Wind
2.14	Temperature
2.15	Waves
2.16	Avalanches
2.17	Earth quake
2.18	Impact
2.19	Explosion
2.20	Fire
2.21	Chem/Phys agencies

Part 3 Resistance models

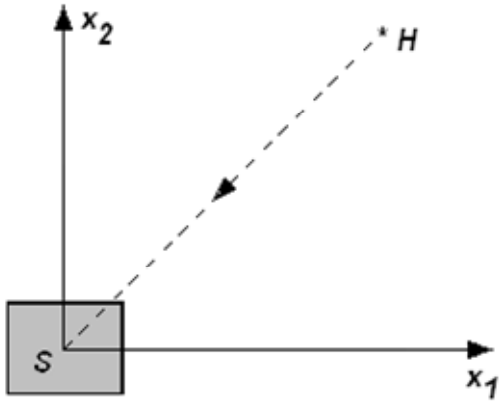
3.0	General
3.1	Concrete
3.2	Reinforcement
3.3	Prestr steel
3.4	Steel
3.5	Timber
3.6	Aluminium
3.7	Soil
3.8	Masonry
3.9	Model uncert.
3.10	Dimensions
3.11	Imperfections

Models for normal loads



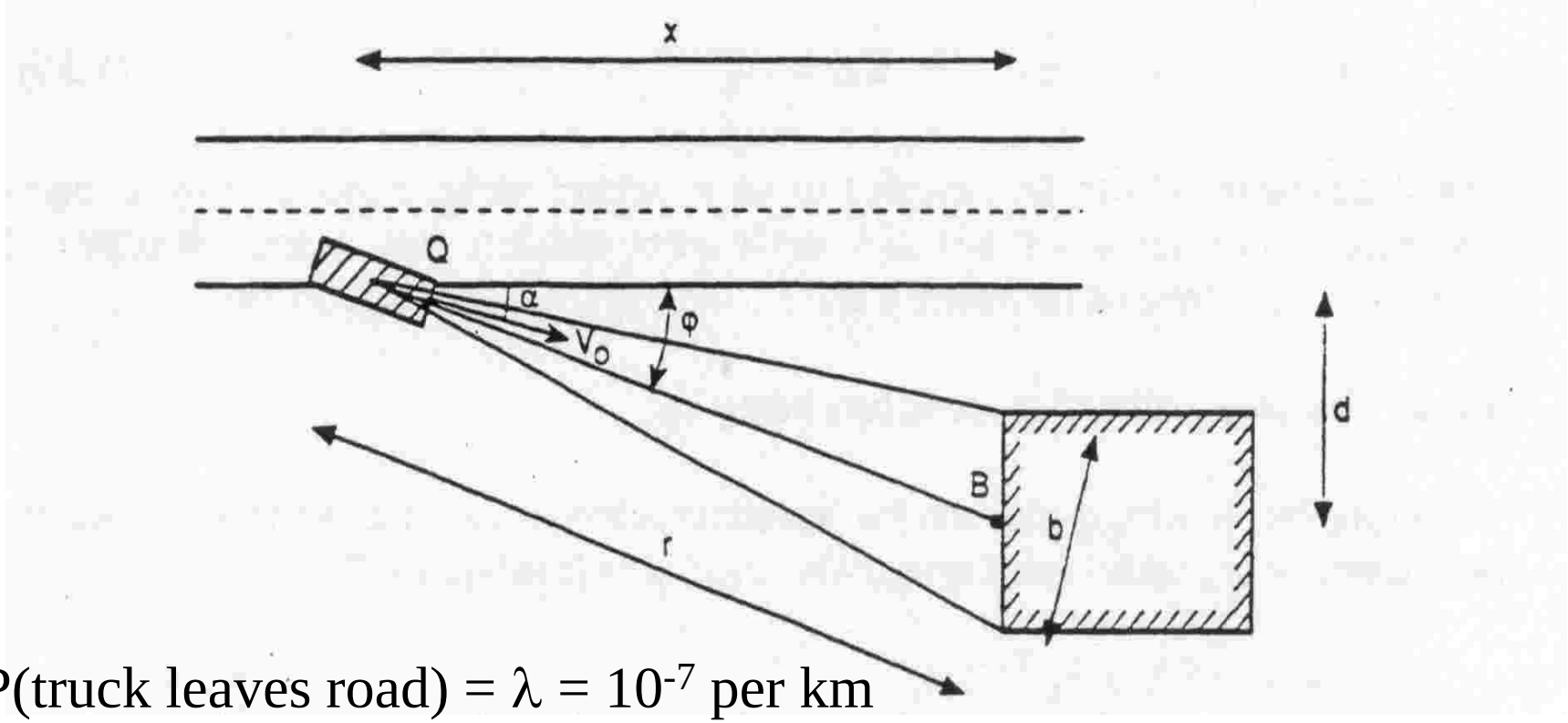
Modelling of accidental actions (natural / man made)

- Triggering event *H* (place **x,** time *t)*
- Magnitude possibly some other parameters.
- Physical interactions (environment, structure S)
- Damage
- Consequences



Components for the extreme event modelling (S=Structure, H= Hazard event)

Impact scenario model

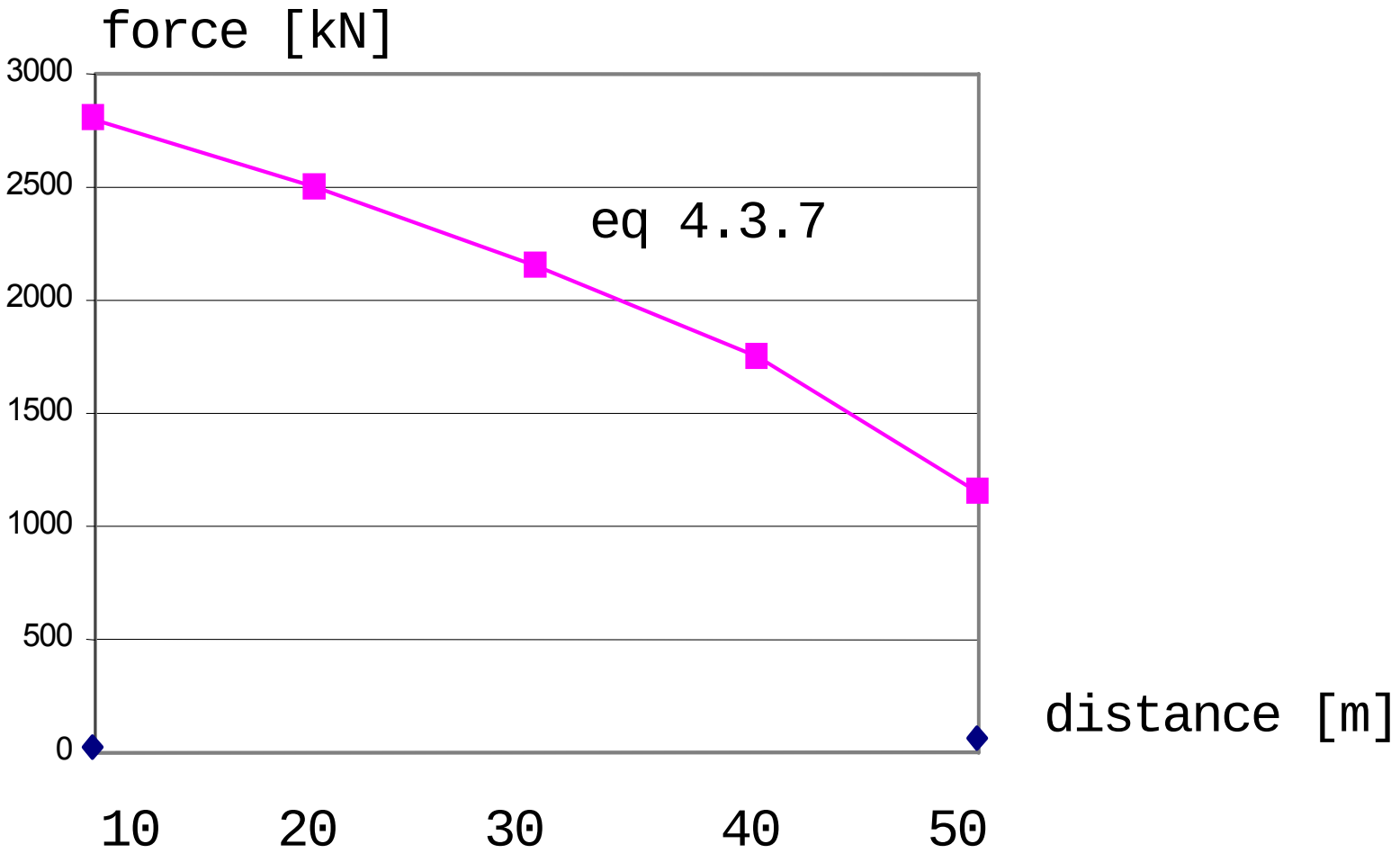


P(truck leaves road) = $\lambda = 10^{-7}$ per km

Force F= v √(km)

Table 4.2.1: Data for probabilistic collision force calculation

variable	designation	type	mean	stand dev
n	number of lorries/day	deterministic	5000	-
T	reference time	deterministic	100 years	-
λ	accident rate	deterministic	10^{-10} m^{-1}	-
b	width of a vehicle	deterministic	2.50 m	-
α	angle of collision course	rayleigh	10^{o}	10^{o}
v	vehicle velocity	lognormal	80 km/hr	10 km/hr
a	deceleration	lognormal	4 m^2/s	1.3 m/s^2
m	vehicle mass	normal	20 ton	12 ton
k	vehicle stiffness	deterministic	300 kN/m	-



Life time exceedence probability: 10^{-3}

INTERNAL NATURAL GAS EXPLOSIONS

$$p_d = \max\{3+p_v, 3+0.5p_v+0{,}04/(A_v/V)^2\}$$

p_d = equivalent static pressure [kN/m²]

A_v = area of venting comp

V = volume of room [m³]

load duration = 0.2 s

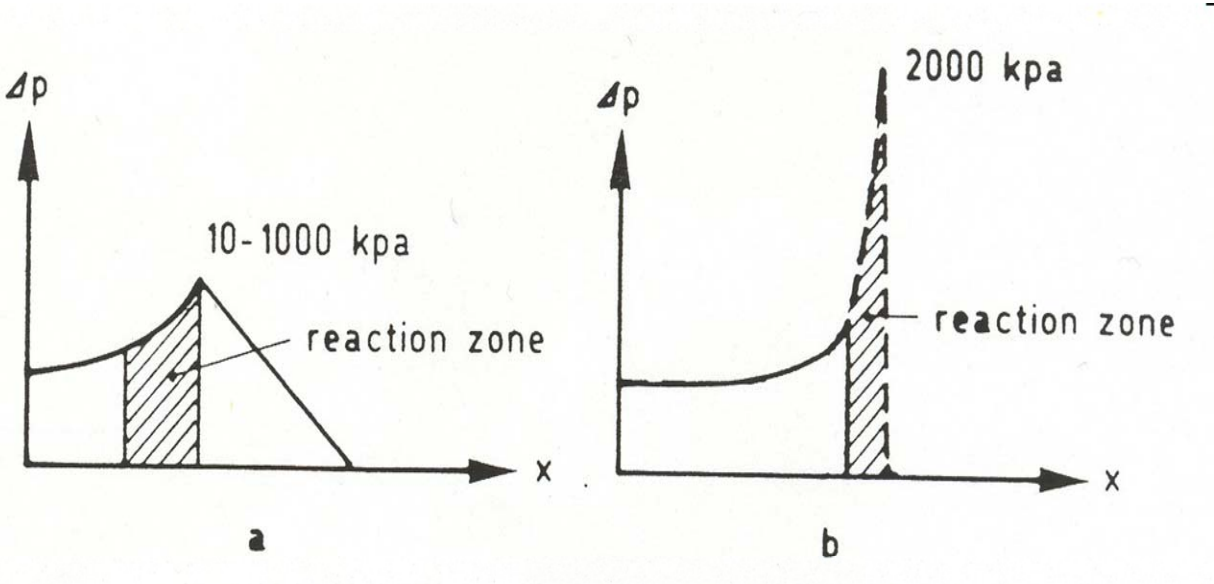
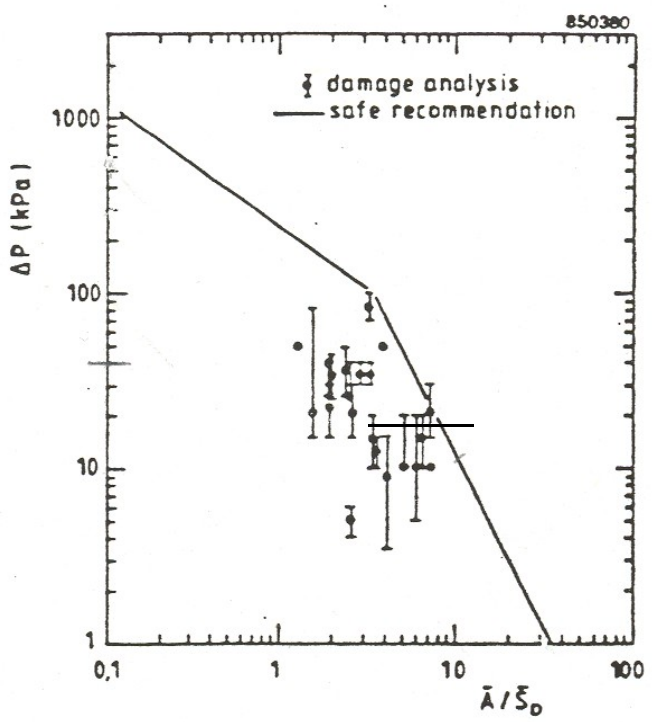


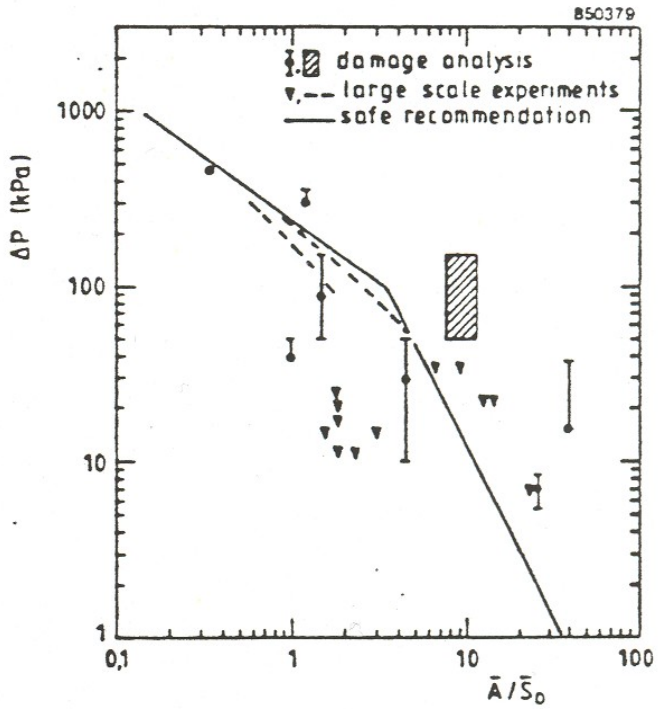
Figure 1: Pressure waves inside the explosion medium: (a) deflagration, (b) detona

UK statistics

	Annual probability of occurrence in dwellings	Possible pressure
Reported explosion but not significant	0.064×10^{-4}	$<<17$ kN/m²
Moderate explosion	0.010×10^{-4}	<17 kN/m²
Severe explosion	0.005×10^{-4}	>17 kN/m²
Very severe explosion	0.0002×10^{-4}	$>>17$ kN/m²

Observed scatter in explosions





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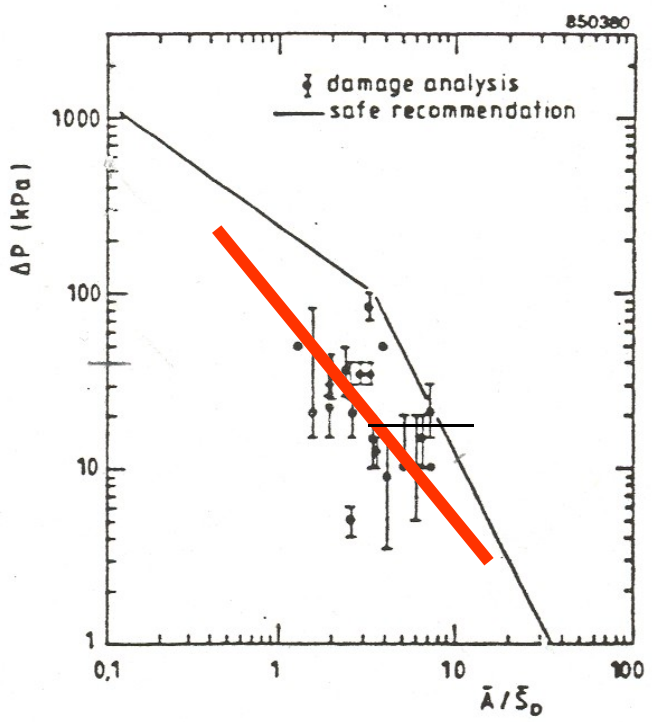

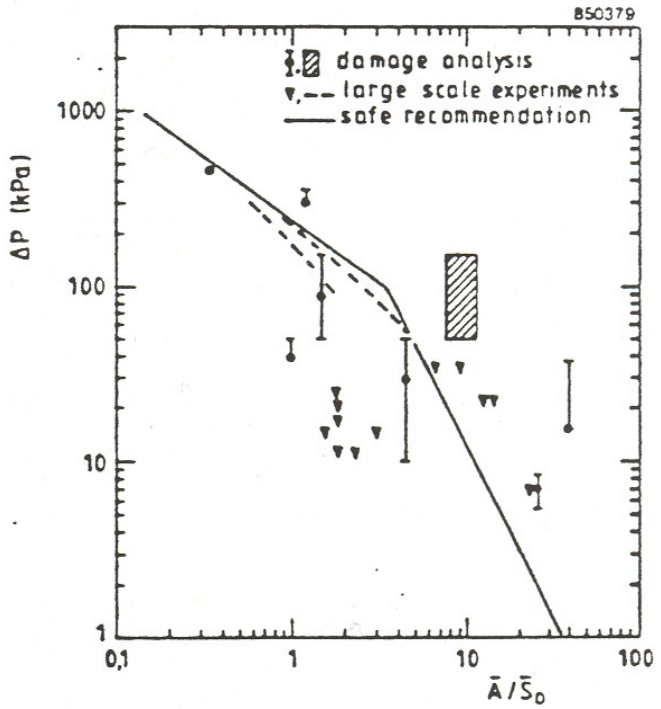

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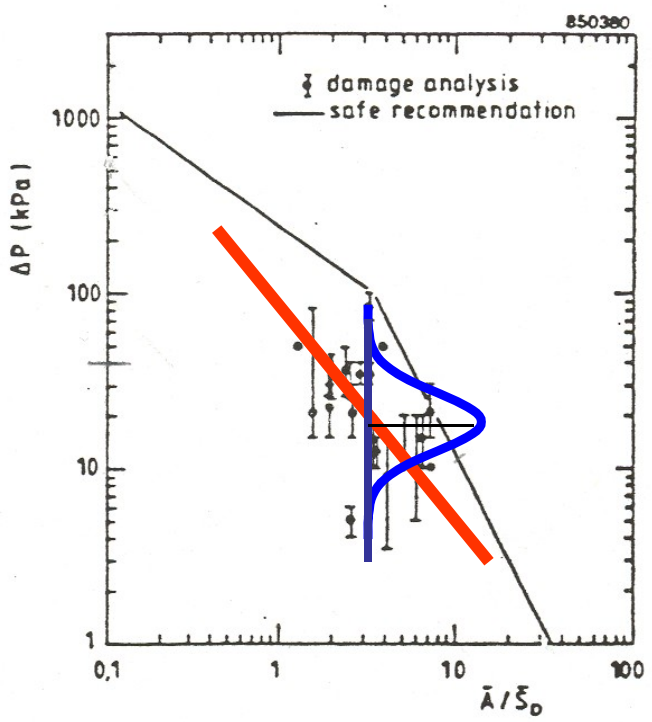

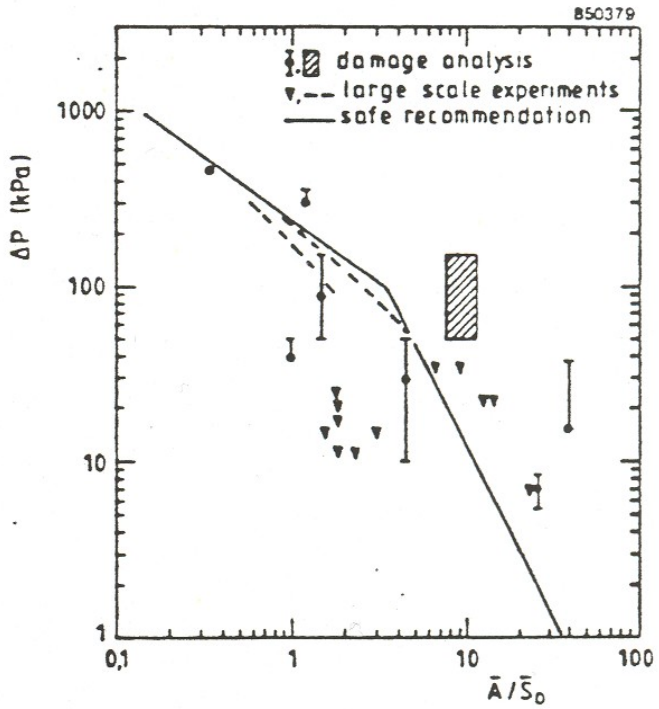

Unidentified conditions

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

Unidentified conditions

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

What is a reasonable probability of the (effects of) unforeseeable, unforeseen or otherwise neglected actions?

Unidentified conditions

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

For discussion: consider an unidentified conditions as included in the list of human errors

- DATA ??

Thomas Bayes

the more data the better

but:

no data = no excuse.