Programm für lebenslanges Lernen

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HOCHSCHULE REGENSBURG UNIVERSITY OF APPLIED SCIENCES

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Seminar: Assessment of existing structures

Codes and Procedures

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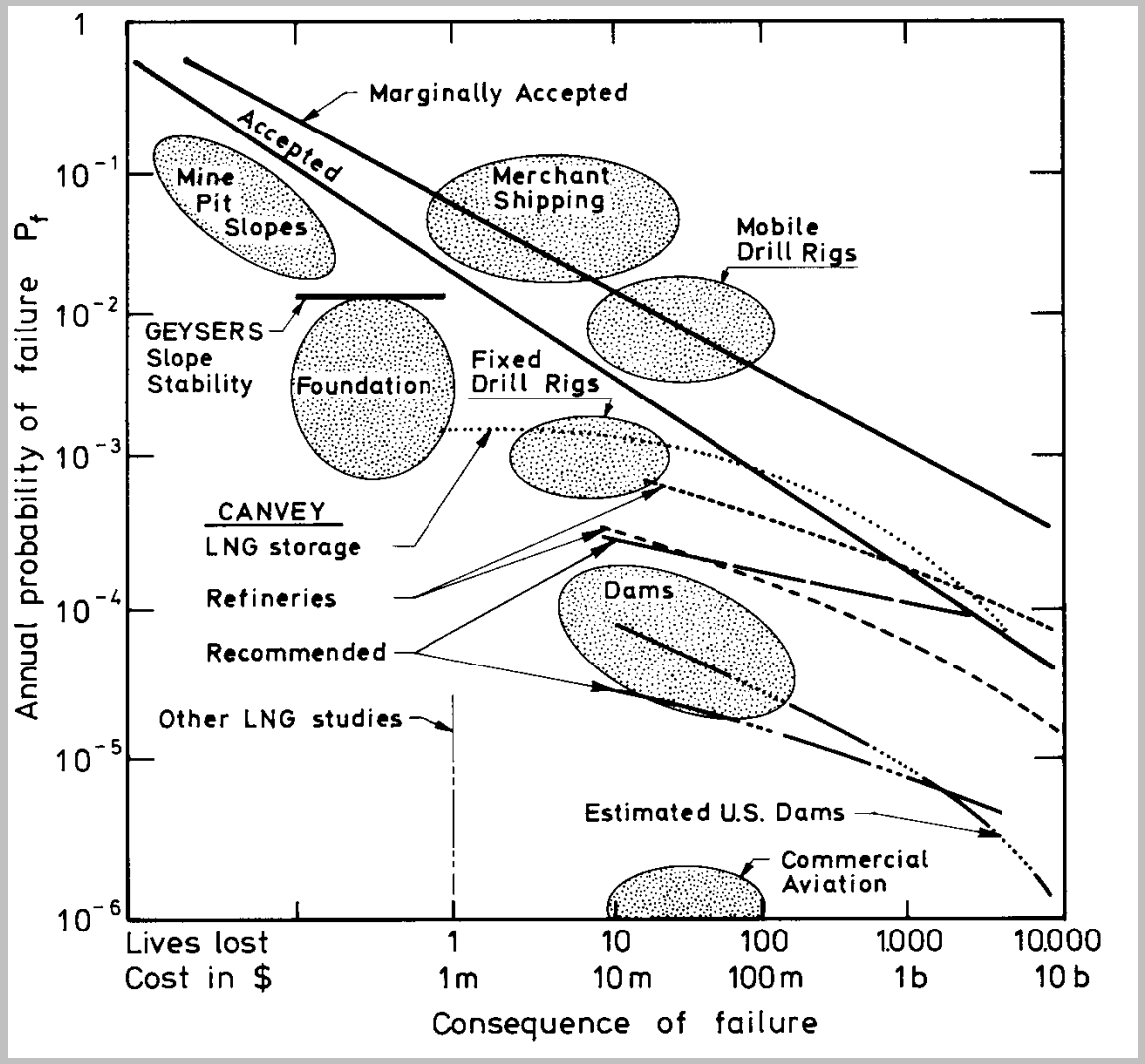
- **Need and criteria for codes and recommendations**
- **Example codes**
- **Example contents with illustrations**
- **Safety acceptance – performance criteria**
- **Applicability to case studies**
- **Future tendencies**

Prague, September, 2013

Why reassess an existing structure?

- Deviations from original design
- Doubts about safety
- Adverse inspection results
- Change of use
- Lifetime prolongation
- Inadequate serviceability

Structural failures experience



Typical questions

- **What type of inspections are necessary?**
- **What type of measurements shall be taken?**
- **What analyses shall be performed?**
- **What is the future risk in using the structure?**

How to find the Answers

- No classical code approach
- New information becomes available
- New techniques can be implemented
- New material technologies can be used
- New decision criteria under new uncertainties

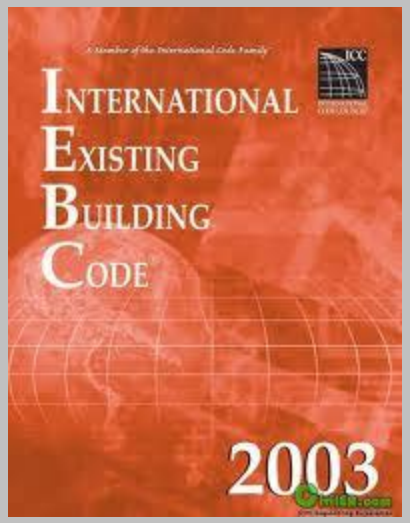
Questions related to codes

- **Are existing structures covered by codes for new structures?**
- **Is there a separate code and to which type of buildings does it apply?**
- **Do codes allow for relaxation or lower performance?**
- **What aspects are covered (inspections etc.)?**
- **What are the governmental regulatory bodies behind?**

Possible requirements for a code on existing structures

- **Applicability**: the code should be applicable to typical assessment cases.
- **Compatibility to codes for new structures**: the code should use the same philosophy as current codes for new structures.
- **Flexibility**: the code should be flexible to include additional information gained by inspection.
- **Ease of use**: the code should be understandable to engineers and easy to use in practice.

Example: Building Code



- **1997 UBC: 2 pages**
- **2000 IBC: 14 pages**
- **2003 International Existing Building Code:**

  67 pages +214 pages Annexes
- **2012 new version 290 pages**

Prenormative and regulatory tools

- **ISO 13822, 2003**
- **ICC Existing Buildings Code, 2009**
- **SIA 462 (Switzerland), 1994**
- **Danish Technical Research Council**
- **ASCE Seismic Evaluation, 2003**
- **ACI 437R -03, 2003**
- **JCSS Recommendations, 2001**

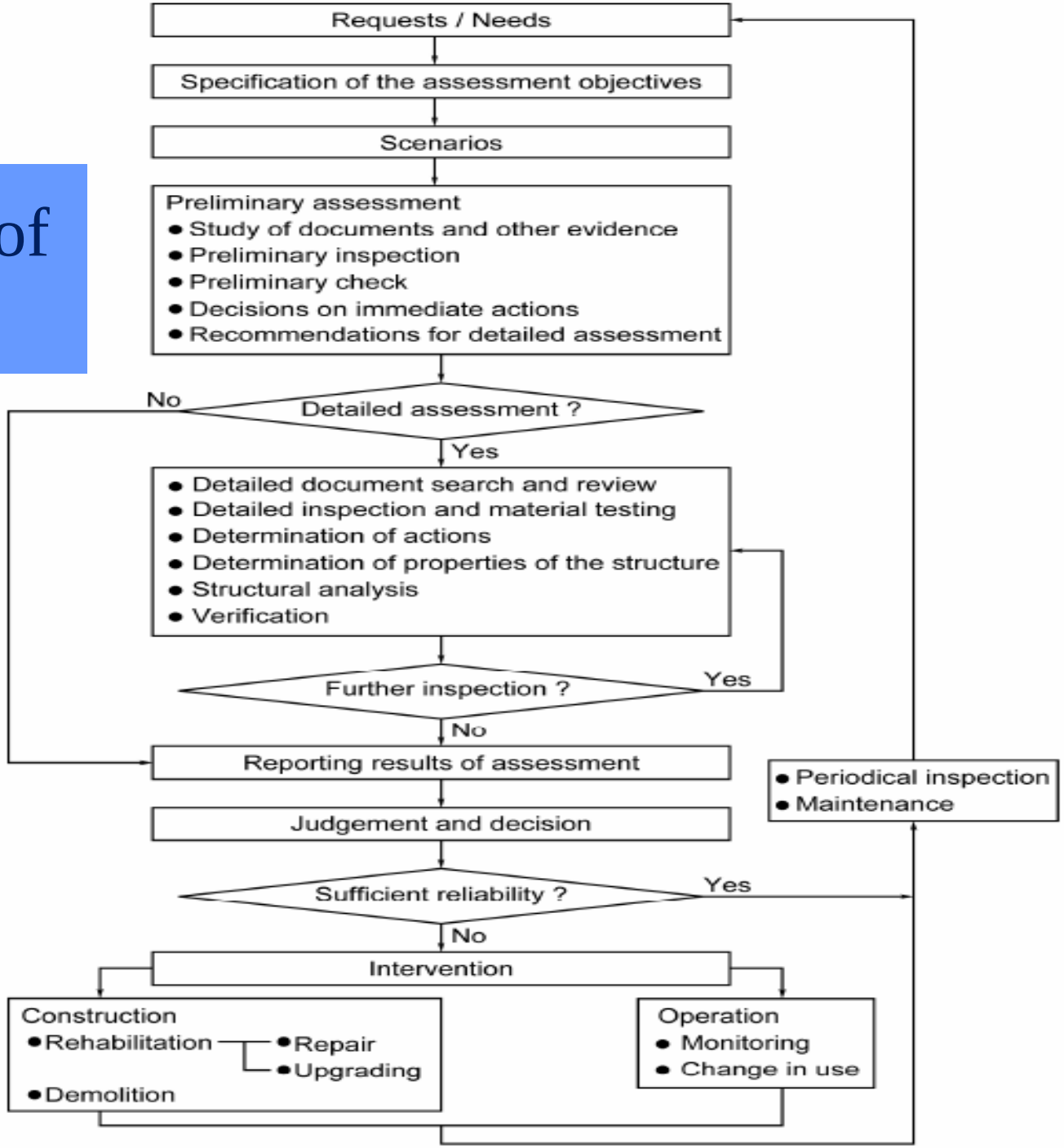
ISO 13822

- **General Framework of Assessment**
- **Data for assessment**
- **Structural Analysis**
- **Verification (Limit State)**
- **Assessment based on satisfactory past performance**
- **Interventions**
- **Report**
- **Judgement and Decisions**

Procedures

General flow of assessment

ISO 13822



Phase: Preliminary Assessment

- Visual inspection
- Review of documentation
- Code compatibility
- Scoring system:
  1. age of the structure
  2. general condition
  3. loading (modifications)
  4. structural system
  5. residual working life

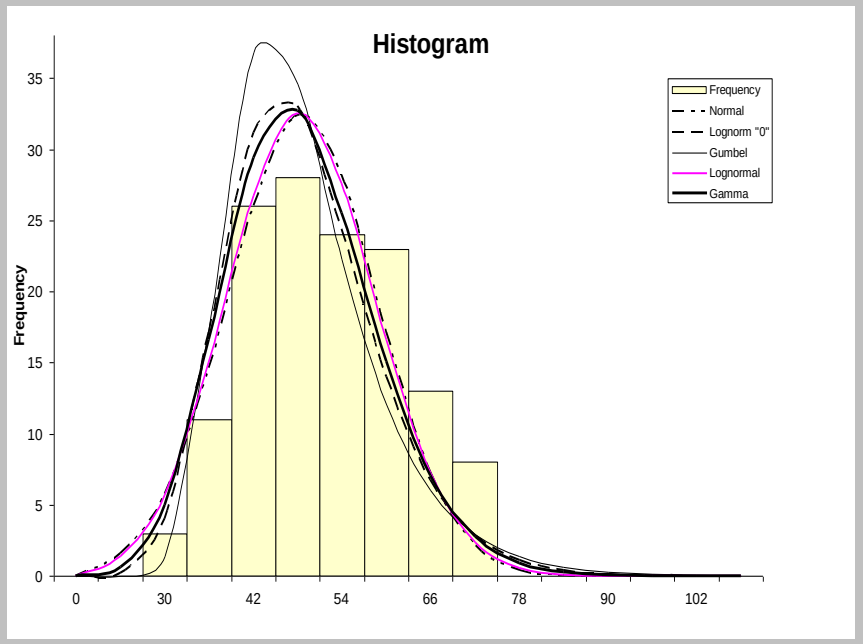
Phase: Detailed assessment

- **Additional inspections**
- **More detailed analyses**

1. **progressive collapse**
2. **full probabilistic**
3. **sensitivity analyses**
4. **risk analyses**

Phase: Detailed Assessment

- Quantitative inspections
- Updating of information
- Structural reanalysis
- Reliability analysis
- Acceptance criteria



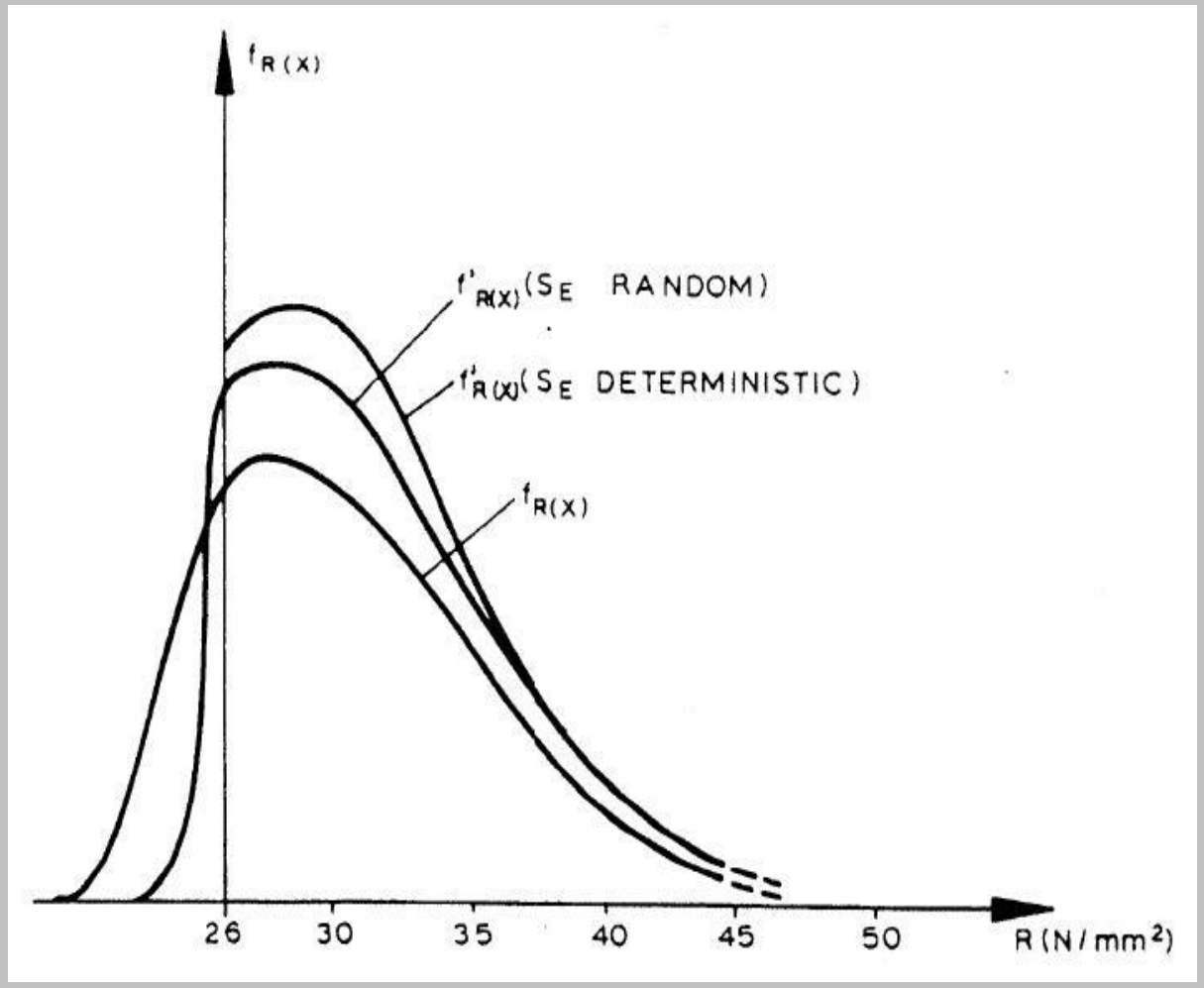
New Information (Updating)

A) Proof Load

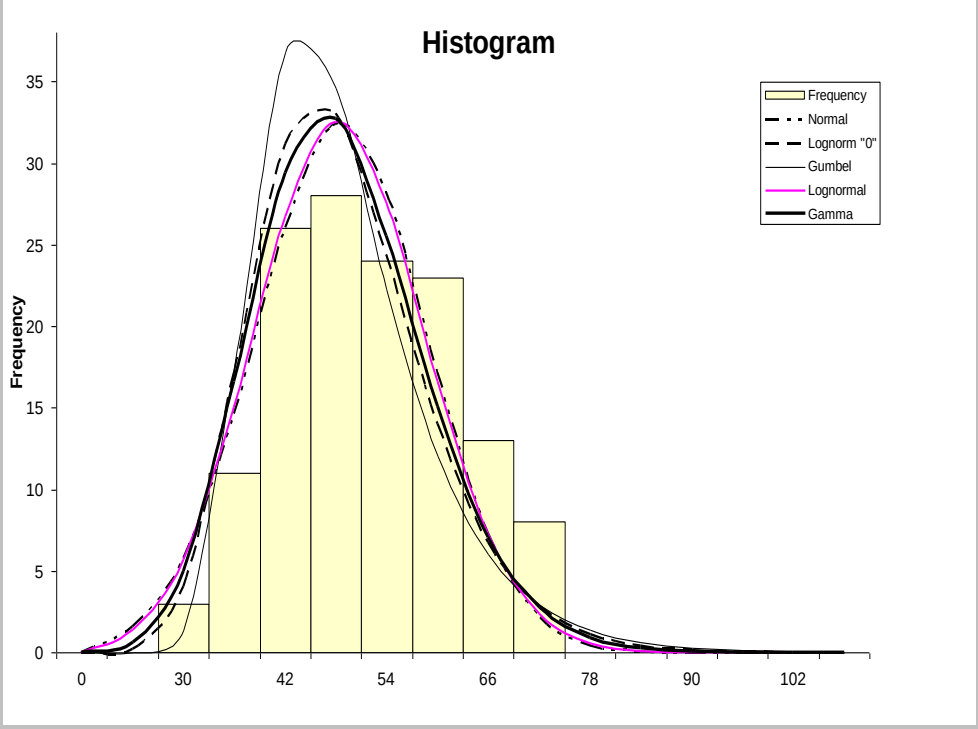
B) Variables (concrete strength)

A) Example: Proof Loading (Survival of a load)

> Updating of resistance



B) Example: Concrete strength data



Decision Criteria

- **Target reliability**
- **Economical considerations**
- **Time constraints**
- **Sociopolotical aspects**
- **Codes and standards**
- **Complexity of analysis**
- **Experience in other fields**

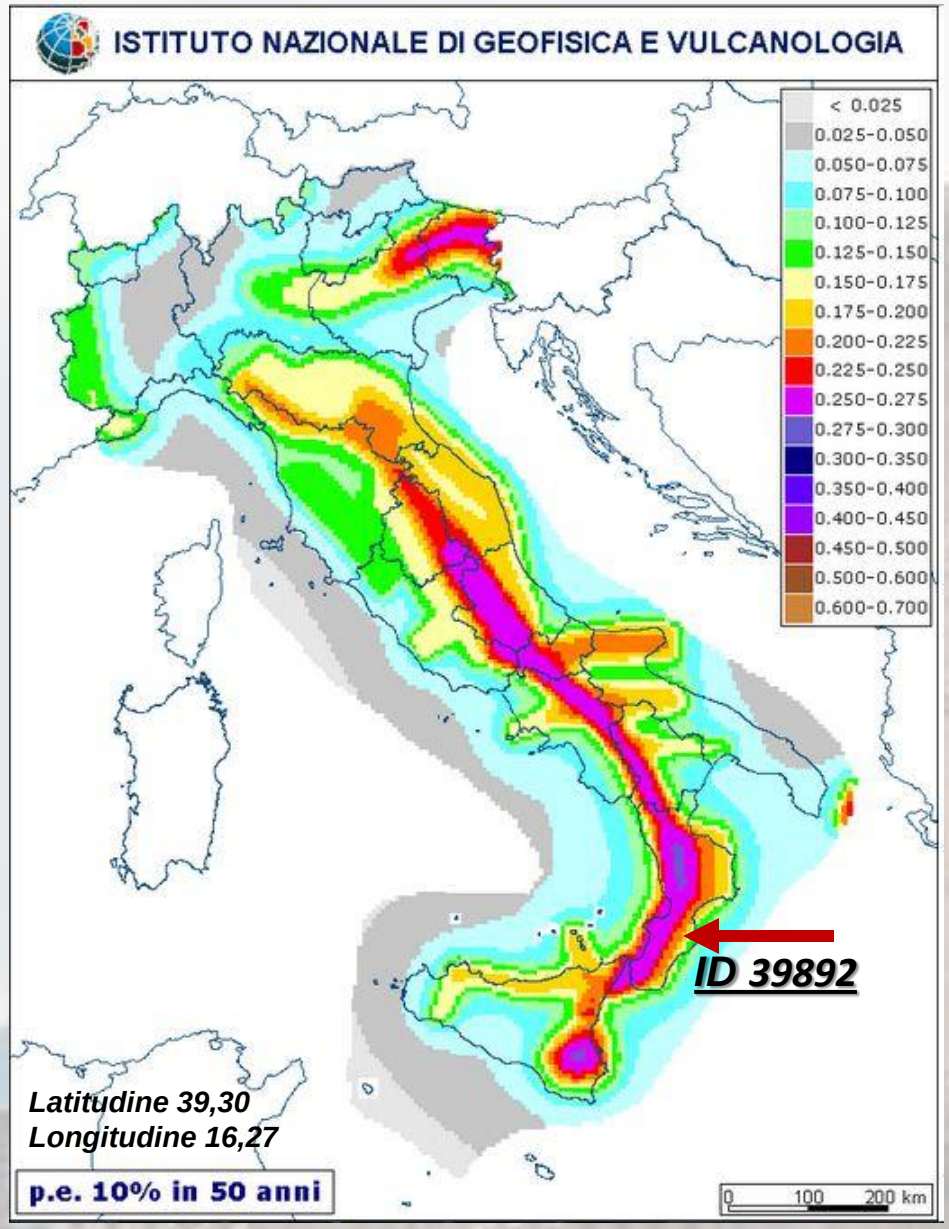
Safety Acceptance Criteria

- **European Experience (limit state verification)**
- **New practice in the US (performance based design)**
- **Optimisation based on LQI**
- **Judgement**

Conclusions regarding reliability acceptance

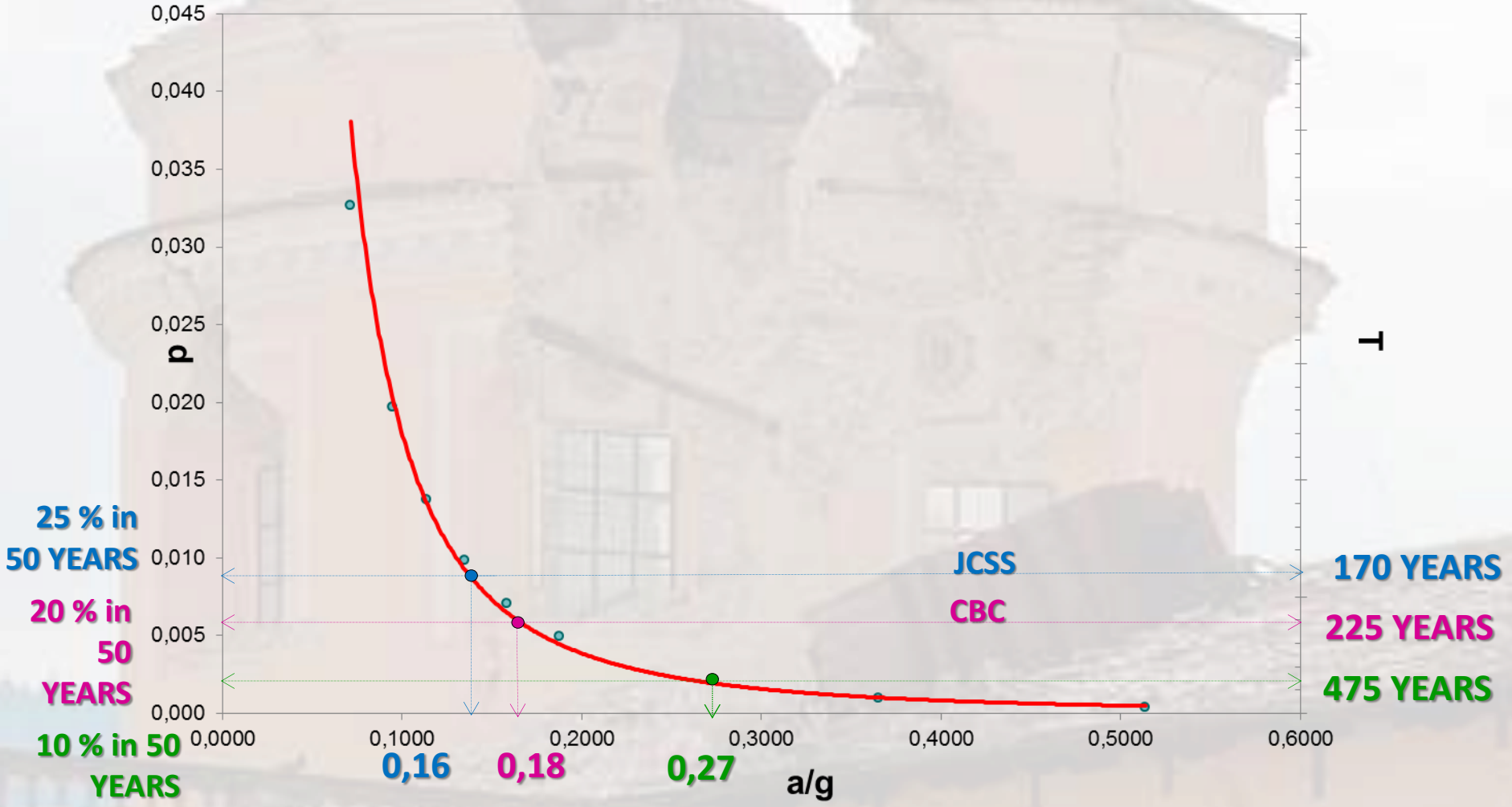
- **A lower safety level compared to a new structure is acceptable**
- **Various criteria have been proposed in the literature**
- **Acceptance criteria depend on cost of safety, consequences of failure, desired residual lifetime**
- **A decrease of the acceptable reliability index ß by 0.5 can be recommended**

Example: Updated earthquake acceleration



Curva di Pericolosità Sismica			
a [g]	T [anni]	p_{50} [%]	p [%]
0,0713	30	81	3,333
0,0944	50	63	2,000
0,1137	72	50	1,389
0,1349	101	39	0,990
0,1581	140	30	0,714
0,1875	201	22	0,498
0,27	475	10	0,211
0,3651	975	5	0,103
0,5138	2475	2	0,040

Seismic hazard curve and updated value due to relaxed acceptance criteria



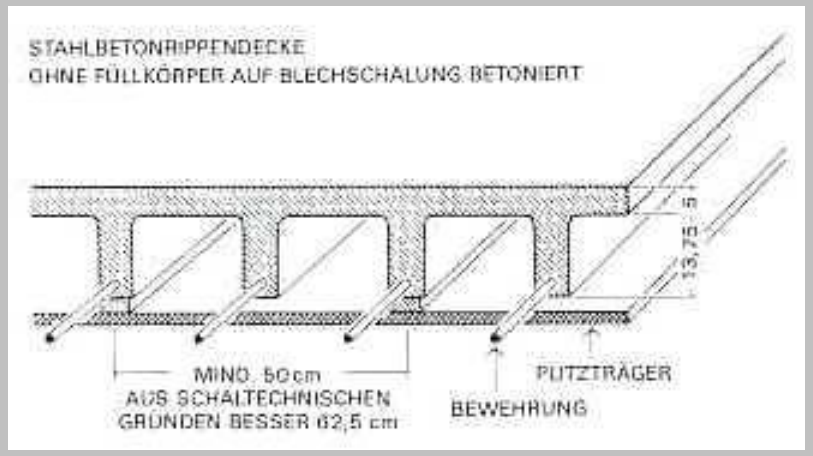
Railway Bridges

- 100 years old
- Scoring system verification

  (foundation, corrosion, joints, supports)
- R (steel resistance) from code on old bridges
- S (train load) from DB

  (German Railways)
- Durability problems

Example: Concrete floor structure (Detailed Procedure)



Reassessment of r.c. floor structure

flexural limit state function

$$g = M_u - M_a$$

M_u: Ultimate Bending Moment

M_a: Acting Bending Moment

Updating of random variables (due to destructive tests)

Variable	Distribution	c.o.v.
Steel strength	Lognormal	0.06
Concrete Strength	Lognormal	0.14
Cover thickness	Lognormal	0.25

Reliability index ß is increased from 3.70 (prior information) to 3.80, due to reduced variability of the parameters

Steel road bridges

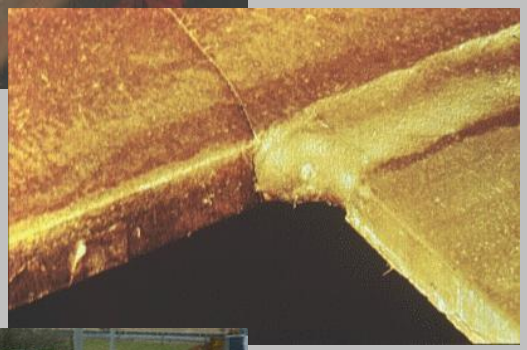
(Phase 3 Procedure)

Typical limit states

- extreme load

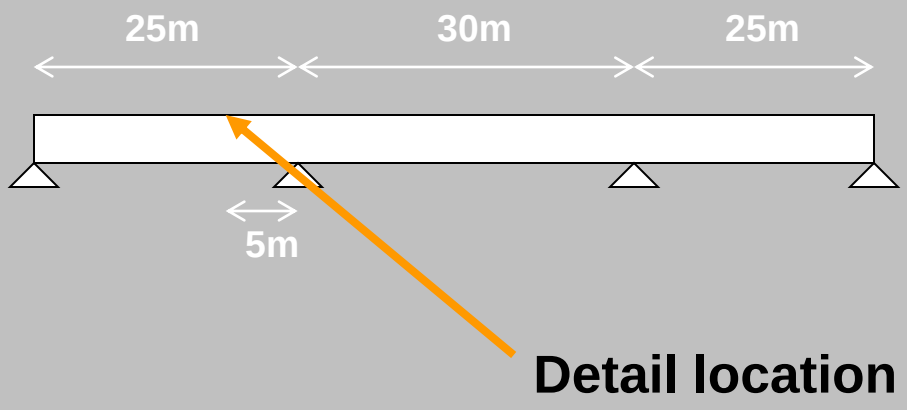
- Fatigue

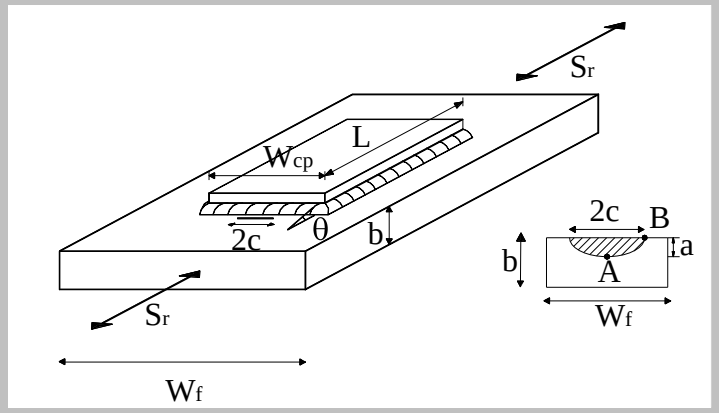
Which measures are necessary in order to meet acceptance criteria (residual life time 20 years)?



Fatigue models

- Fracture Mechanics approach
- Crack growth propagation
- Influence of inspections (measurement of cracks)



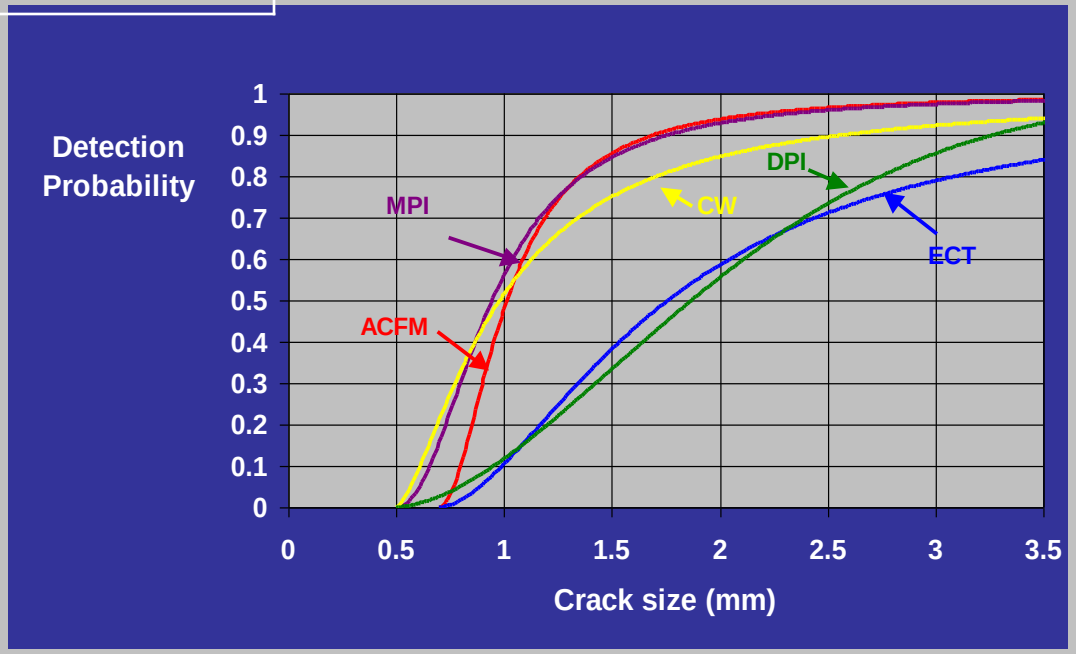


Cover plate detail

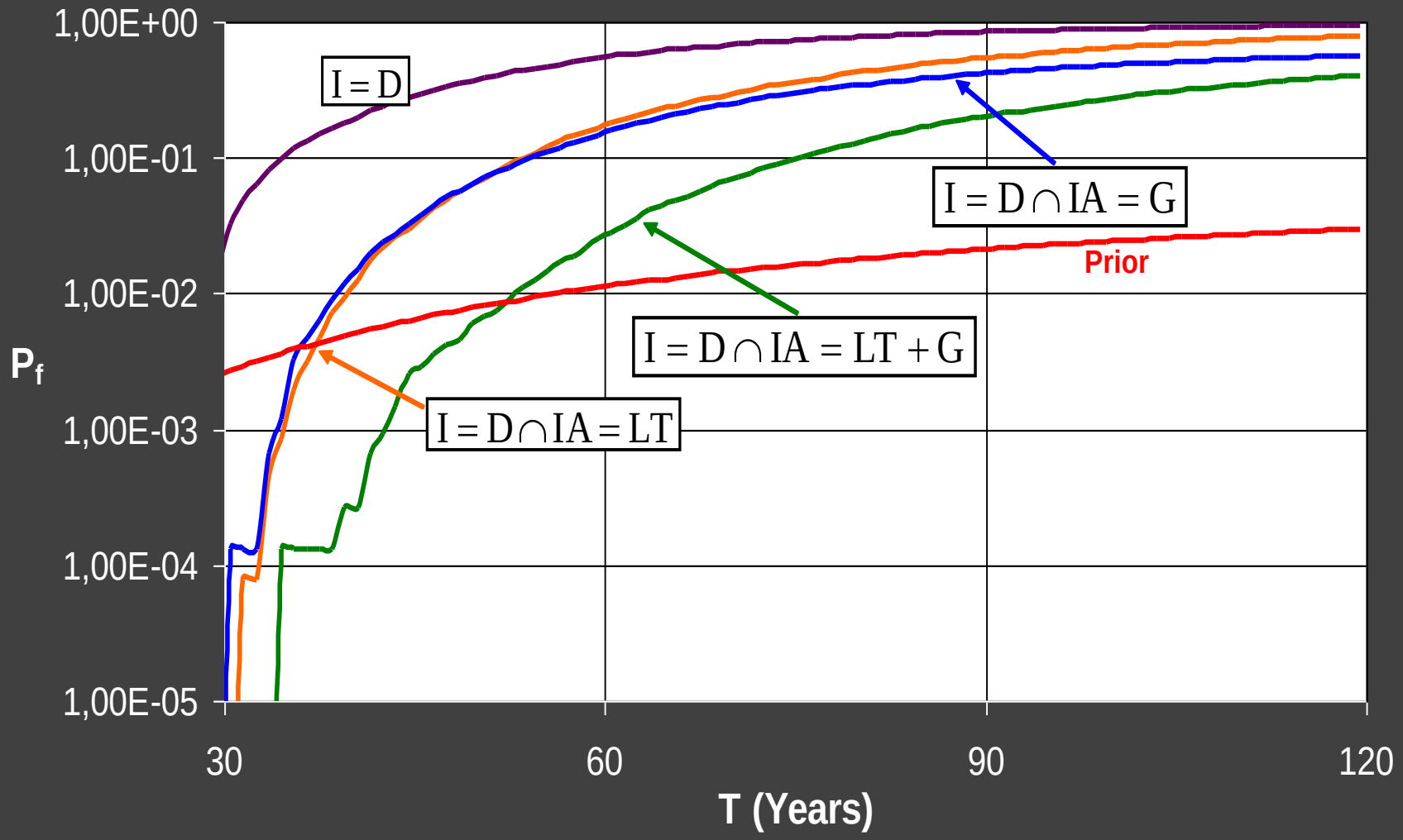
Fatigue assessment: Random Variables (examples)

Variable	Distribution	Type
a_d	POD*	Inspection
a_g	Uniform	Repair
a_{fail}	Derived	Mixed
S_r	Rayleigh	Load
S_{max}	Gumbel	

* POD for MPI used in case study



Fatigue assessment: typical results



I: Inspection, D=Detection

IA: Invasive Action, LT=Load Truncation, G=Weld Toe Grinding

Fatigue assessment: scenarios

- **Inspection and crack detection at T=30y**
- **Alternatives considered:**
  1. **Load truncation (LT)**
  2. **Weld toe grinding (G)**
  3. **Load truncation + weld toe grinding (LT+G)**

Future tendencies

- No classical code approach
- Quantification of new information
- Updated design values
- Uncertainties (climate change etc.)
- Relaxed acceptance criteria
- Robustness aspects

Thank you for your attention