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Seminar: Assessment of existing structures

Assessment and Procedures

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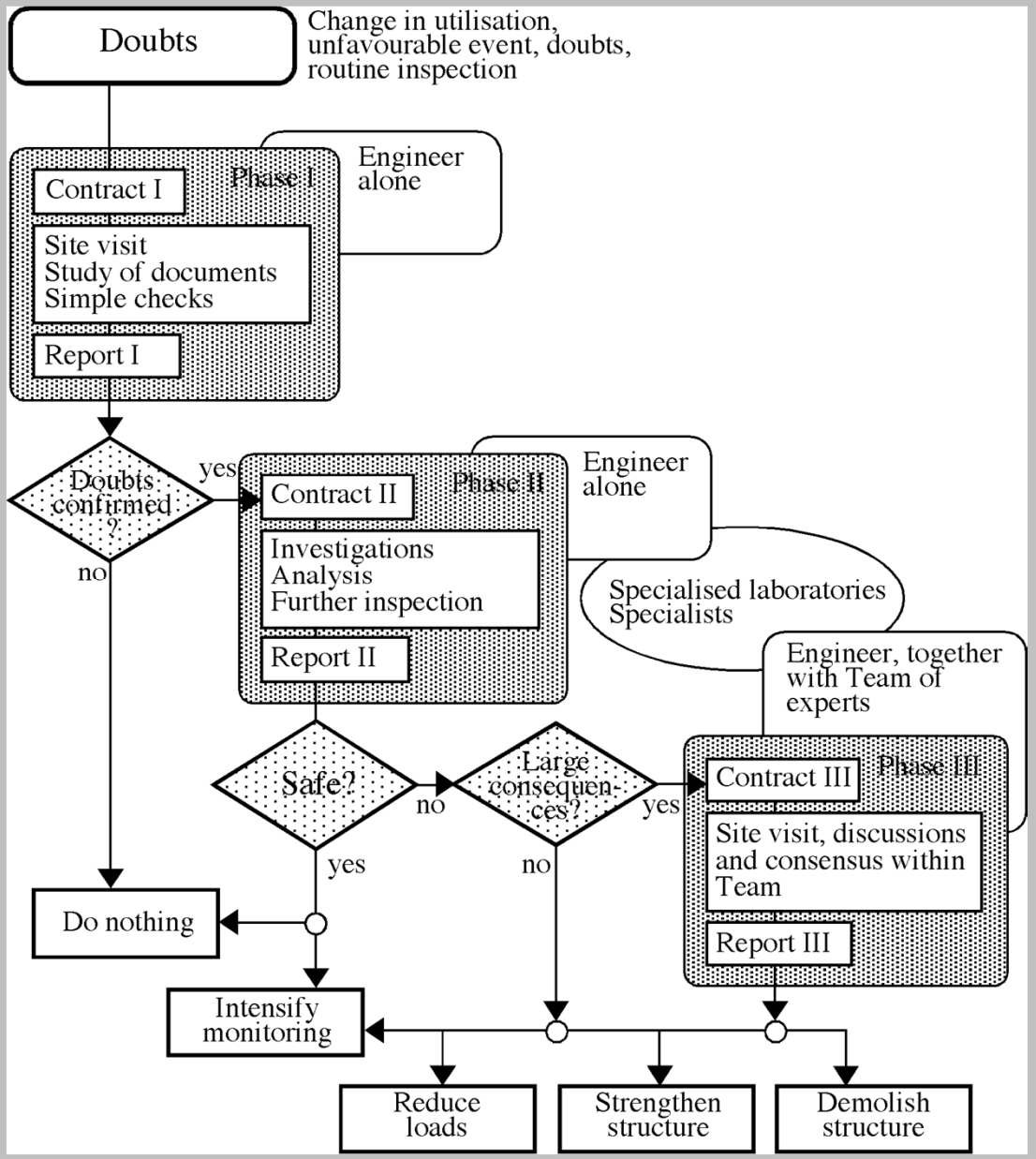
Parthenon

From 448B.C - 2007

Decision Criteria

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

Assessment Process

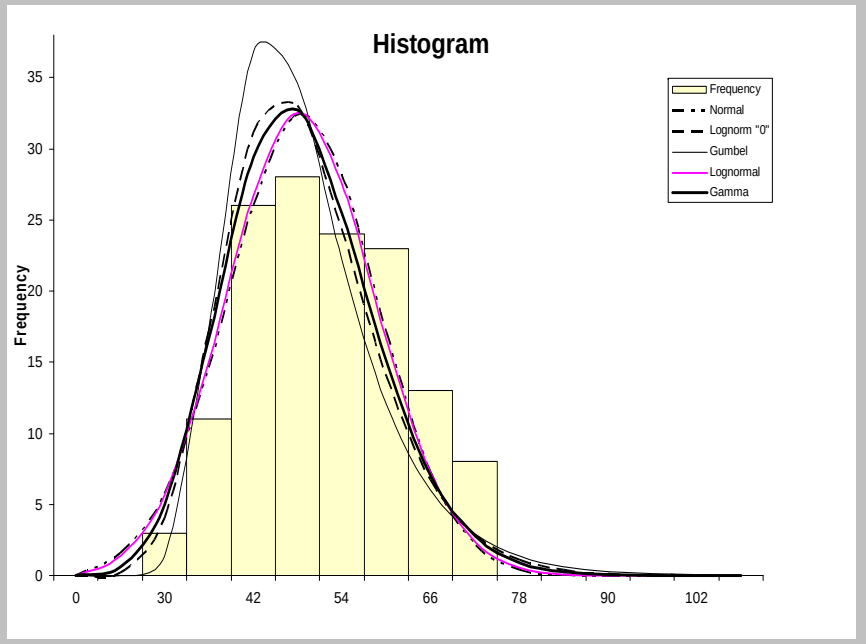


Phase 1:Preliminary Assessment

- 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 2: Detailed Assessment

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



Phase 3: Expert team

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

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

Old Railway Bridges
(single span systems)

Old railway bridges
Phase 1 Procedure

Railway Bridges

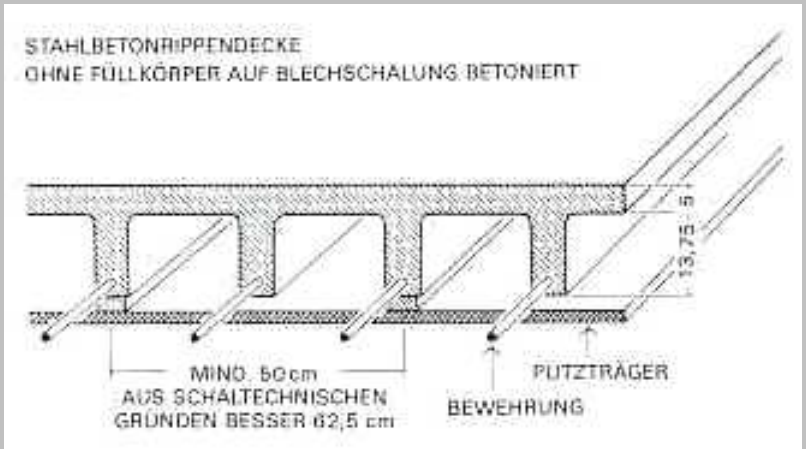
- 100 years old
- Scoring system verification

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

R.C. Buildings in Germany

- **Office building**
- **Concrete construction**
- **70 years old**
- **Reduced load in order to satisfy minimum safety**

Example Concrete floor structure (Phase 2 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

Two Cases for Updating

- **Case a) Updating of random variables (due to destructive tests)**

- **Case b) proof load = 4x design load**

Case a) 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

Case b) proof load

- **Partial proof test until collapse resulted to a very high proof load**
- **Artificial limit state function**

$$g = M_{proof} - M_u <= 0$$

- **Computation of conditional failure probability**

=> Reliability index ß is increased from 3.90 to 4.90

Steel road bridges

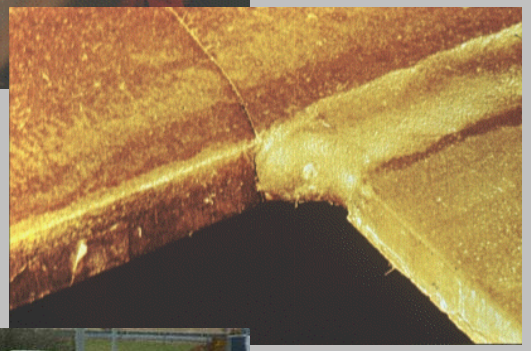
(Phase 3 Procedure)

Typical limit states

- extreme load

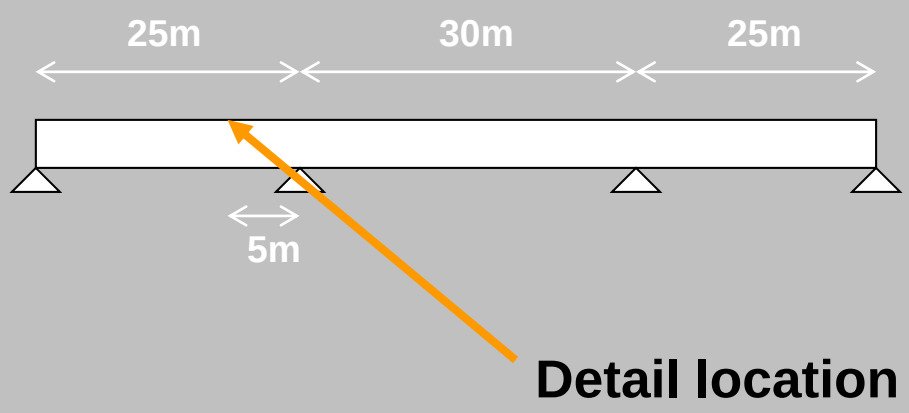
- Fatigue

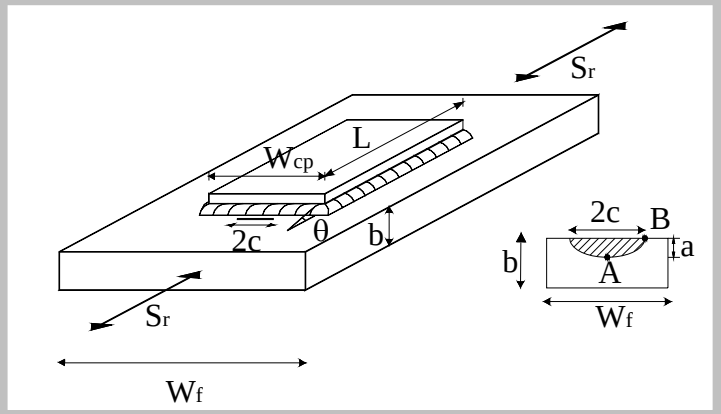
Which measures are necessary in order to meet acceptance criteria (residual life time 20 years)?



Fatigue models

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



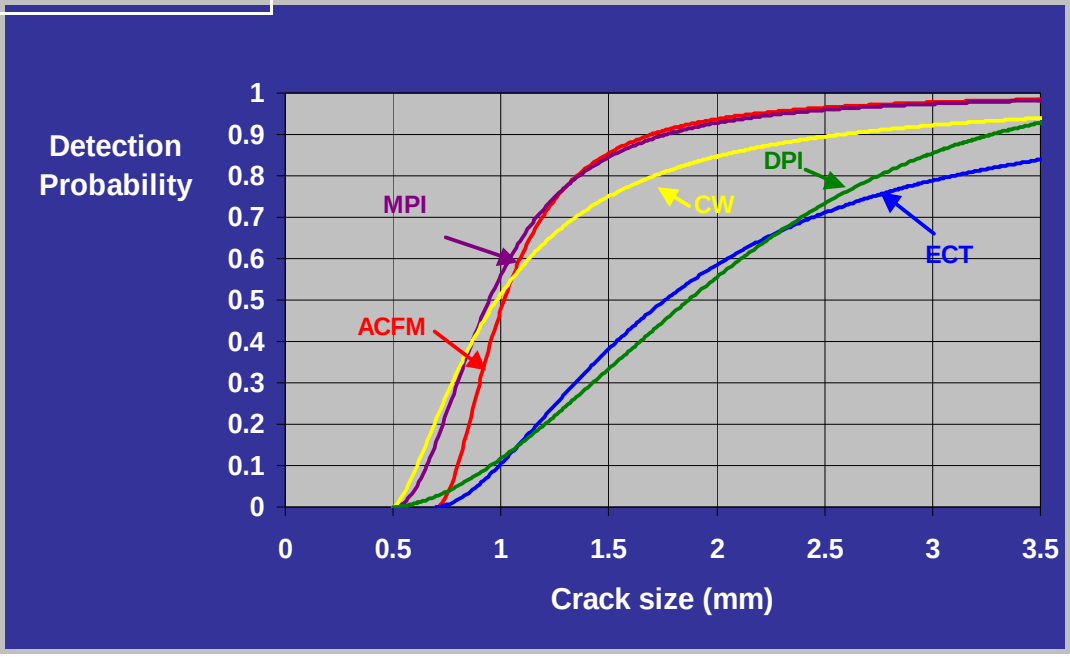


Cover plate detail

Fatigue assessment: Random Variables (2)

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: 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)**

Existing tunnels in Europe

- **Accidents in Europe (fire)**
- **Dangerous goods**
- **Bi-directional traffic**
- **Increasing traffic**
- **High consequences**

➢ **New standards (2004)**

➢ **Safety reassessment of more than 400 tunnels!**

Road Tunnel in Greece: the problem

- Korinth-Tripolis (PPP-Projekt)
- Bidirectional traffic (2-3 years)
- Length 1365m
- Inclination 1%.
- 20 years old

> safety reassessment

Tunnel in Greece: methodology

Hazard probability levels

Class	Frequency	Events / year
A	frequent	>10
B	occasional	1-10
C	remote	0.1-1
D	improbable	0.01-0.1
E	incredible	0.001-0.01

Hazard severity levels

Class	Severity Category	Human losses
1	insignificant	---
2	marginal	injuries
3	critical	1
4	severe	5
5	catastrophic	50

Risk Acceptability Matrix

AL: ACCEPTABLE

NAL: NOT ACCEPTABLE

ALARP: PRACTCABLE

	1	2	3	4	5
A	**ALARP**	**NAL**	**NAL**	**NAL**	**NAL**
B	**ALARP**	**ALARP**	**NAL**	**NAL**	**NAL**
C	**AL**	**ALARP**	**ALARP**	**NAL**	**NAL**
D	**AL**	**AL**	**ALARP**	**ALARP**	**NAL**
E	**AL**	**AL**	**AL**	**ALARP**	**ALARP**

Road Tunnel in Greece: conclusions

- EU-standards NOT satisfied (escape routes)
- High Upgrading costs
- Safety is Acceptable (Risk Matrix Approach, Cost Benefit Analysis)
- Implementation of economical safety measures (illumination)