

IRIS – Integrated European Industrial Risk Reduction System CP-IP 213968-2



Measuring the Age of Concrete

The Civil multi non-linear Condition Model

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Risk = Hazard * Impact





1. August 1976 - Aug. 1st 2007



→Help from Monitoring?→Focus Dynamics









Motivation for Health Monitoring I-35 Collapse, Minnesota, 2007











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Bridge Deficiency Summary









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[S. Chase, FHWA 2007]





- \rightarrow FHWA operates 600000 bridges
- \rightarrow 165000 are rated deficient (28%)
- \rightarrow 12000 are seriously deficient (2%)
- →Value about € 96 bn
- \rightarrow Upgrade rating for 25% of them
- \rightarrow Discount rate 6%
- →We save 1,44 bn € per year



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A more complete Model



Risk = Hazard * Impact

Impact = Vulnerability (physical) * Consequences (economic) * Uncertainties (physical and non physical)











Uncertainty factors θ_k contain



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- → the aleatory uncertainties, namely those facts that are not yet known, sufficiently studied or properly formulated for application in the assessment routine
- → the epistemic uncertainties which are evident in every physical process. They depend on the quality of the available data and information for the respective structure
- → the nature of the Hazard under consideration of a specific return period and the circumstances like sudden or early warning
- the psychological impact factor reflecting the individual tolerance to risk.
 How risk is perceived will considerably influence the decision making process
- → the duration of exposure (short time, long time or forever) and quantifies the consequences
- → a cultural factor, based on the socio cultural differences between the different regions and adjustment of eventual consequences can be made









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Time dependence

• **Integrated European Industrial Risk Reduction System** CP-IP 213968-2

Concept and Approach

Structural Performance over Time









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Next Monitoring Generation





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 $[m] \cdot \{ \ddot{z} \} + [\xi] \cdot \{ \dot{z} \} + [k] \cdot \{ z \} = \{ F \}$



e.g. for non-linearity

























































Uncertainties ?







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Improvement over time







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[Frangopol, 2008]





Radiation Extreme

















Pier Condition after Ship Impact?




On line condition assessment













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STACK PERFORMANCE in STORM KYRIL



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The smockestack's monitoring system consists of 12 measuring channels (sampling rate 250 Hz), representing effective accelerations, the dilatation of two selected vertical cracks, wind speed and wind direction and temperatures at several locations.



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→ Seismic Qualifikation of Civil Engineering Structures







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Scope of Risks addressed







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A1/S101 Dezember 2008





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Visuelle Inspektion







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Accumulated Energy Function



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Europabrücke Checking period: 1997–nov

Europabridge, at lunchtime 750 600 500 450 400 300 300 300 300 8 8 ms 380 360 340 320 5 300 280 260 8 240 220 200 180 160 22 140 120 100 80 -60 -40 -20 -4 규 300 250 200 350 8 \$ 1.00 0.95 0.90 0.85 0.80 0.75 0.70 0.65 0.60 8 0.55 0.50 0.45 0.40 0.35 0.30 0.25 0.20 0.15 0.10 0.05 Ŧ 0.00

800 ms 8 250 8 35 600 550 450 22 800 750 700 10 650 600 550 500 450 400 350 300 250 200 150 100 -50 폾 1.00 0.95 0.90 0.85 0.80 0.75 0.70 0.65 8 0.60 0.55 0.50 0.45 0.40 0.35 0.30 0.25

Europabridge, at midnight

Risk assessment

0.20

0.15 -

0.10

0.05

0.00





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Risk Level: low

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Melk B3A

Risk assessment



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Checking period: 2000-2009











Risk Level: high

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Vienna Airport Approach Bridge



Hz

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- \rightarrow Built in 1956
- → Widened in 1968

→ Checking period: 2000-current

Risk assessment






IRIS Safety Culture







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