ACESSIBILITY & TRANSPORTS

Project nr 2008-1/049

UNIVERSITÉ DE NANTES · EP Estradas de Portugal, S.A.

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7th Trans-national Workshop

Lisboa • LNEC • 30th May 2012

Maintenance Optimization and Decision Tools for Infrastructures in Atlantic Area

Franck Schoefs, LUNAM Université, U. of Nantes, France
and all the partners of WG2 (TCD, U. Bordeaux, EP)

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Problem Definition

For a given structure how do we decide upon the optimal maintenance strategy as a function of age, condition, importance, <u>required remaining life</u> etc. in a robust/repeatable manner, avoiding generalisation/excessive conservatism such that our maintenance budget is optimised???

e.g. *Storstroem 1937, 3.2km*

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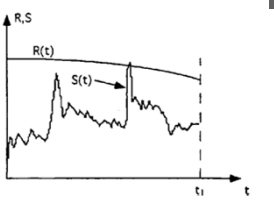
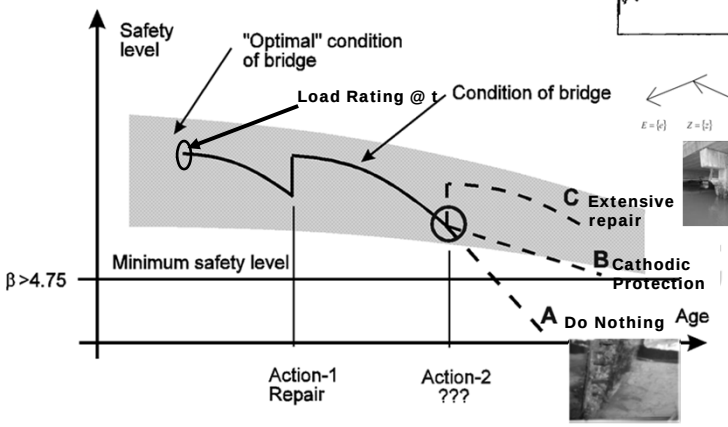
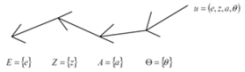
Problem Definition







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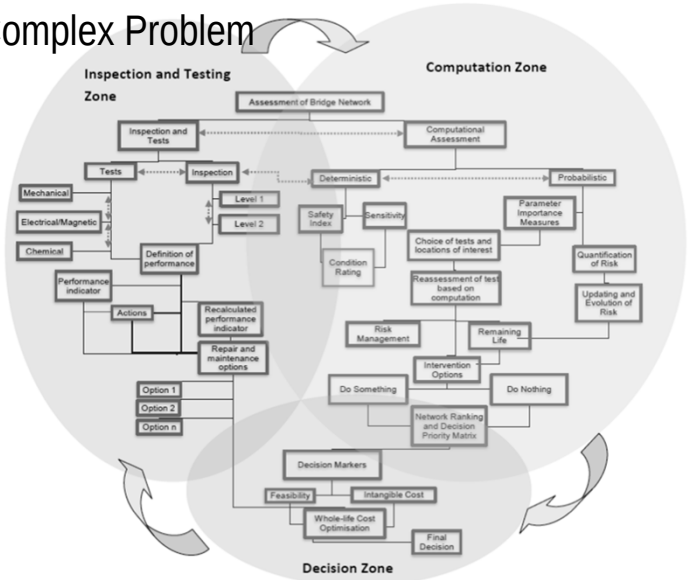
A Complex Problem



Interactive Infrastructure Maintenance Management: Hierarchical "Mandala"

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Hierarchical Methodology

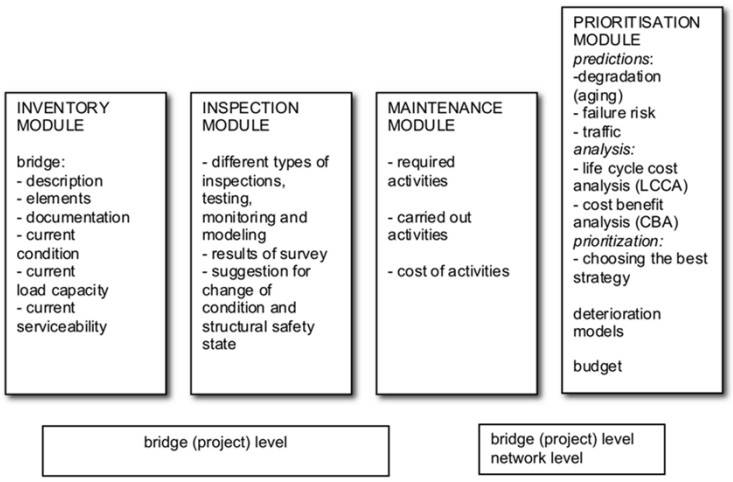


Figure 2.1 Structure and information flow scheme of Bridge Management System (NCHRP, 2003).

Adaptation to the practice

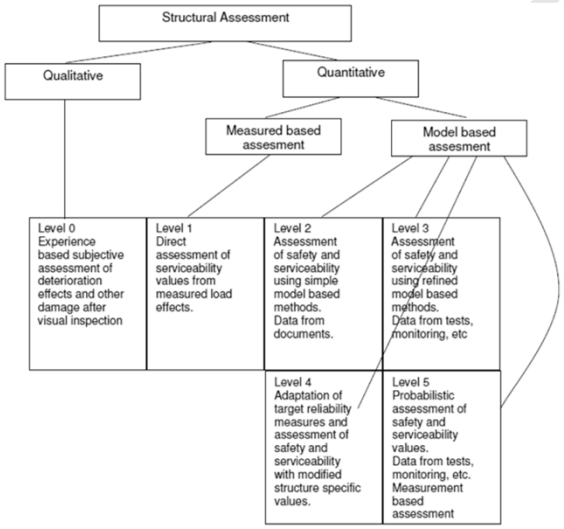
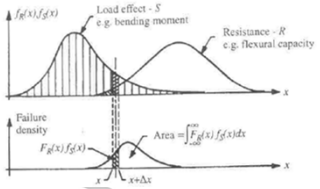


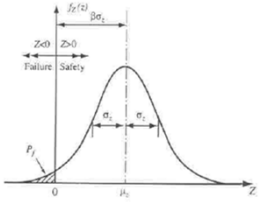
Figure 3.2 Structural Assessment Levels (SAMCO, 2006)

Some technical aspects

Statistical Modelling of:
Loads
Resistances
Uncertainties
Updating based upon results of tests/inspections

Purpose:
Cut strengthening or rehabilitation costs without compromising the safety level





Essentially a Bridge specific "code" is obtained

Probability Based Maintenance Optimisation

Legal Basis – Eurocode 1 Basis of Design

Safety Level NEVER Compromised – Rather Optimised

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1990

April 2002

English version

Eurocode - Basis of structural design

3.5 Limit state design

(1)P Design for limit states shall be based on the use of structural and load models for relevant limit states.

(2)P It shall be verified that no limit state is exceeded when relevant design values for
– actions,
– material properties, or
– product properties, and
– geometrical data
are used in these models.

(3)P The verifications shall be carried out for all relevant design situations and load cases.

(4) The requirements of 3.5(1)P should be achieved by the partial factor method, described in section 6.

(5) As an alternative, a design directly based on probabilistic methods may be used.

NOTE 1 The relevant authority can give specific conditions for use.

NOTE 2 For a basis of probabilistic methods, see Annex C.

(6)P The selected design situations shall be considered and critical load cases identified.

(7) For a particular verification load cases should be selected, identifying compatible load arrangements, sets of deformations and imperfections that should be considered simultaneously with fixed variable actions and permanent actions.

(8)P Possible deviations from the assumed directions or positions of actions shall be taken into account.

(9) Structural and load models can be either physical models or mathematical models.

Few Examples

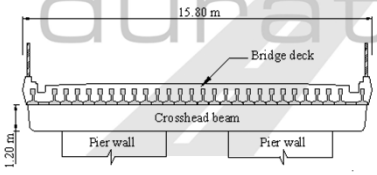
from

Portugal,

Ireland,

France

Ferrycarrig Bridge



Alternative Repair Options

Crossshead 1,7: Cem 1 OPC, 50mm cover
Crosshead 2: Cem 1 OPC, 70mm cover
Crosshead 3: Cem 1 OPC, silane surface treatment
Crosshead 4,6: Cem 1 OPC, 60% GGBS
Crosshead 5: Cem 1 OPC, mixed in corrosion inhibitors

Probabilistic Assessment

Torsional Capacity of Crosshead Beams

•Failed in Deterministic Assessment

•Passed in Probabilistic Assessment

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Barra Bridge, Portugal

	Resistance capacity before repair (kN.m)	Resistance capacity after repair (kN.m)
Pier 8	-319730	-364150
Mid-Span	20 460	22100

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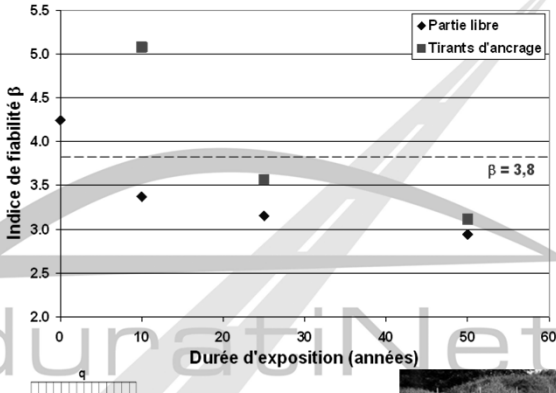
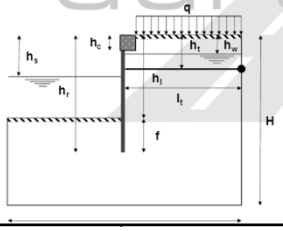
Steel Wharf, France





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Economic Implications

Bridge	Conventional Approach	Probabilistic Approach	Saving
	Max 40 t	Max = 100 t	
Vilsund	Life = 0	Life > 15 yrs	€3.2 m.
Skovdiget	Life = 0	Life > 10 yrs	€12 m.
Storstroem	Max = 50 t	Max = 100 t	€16 m.
Klovtofte	Max = 60 t	Max = 150 t	€1.6 m.
407-0028	Max = 45 t	Max = 100 t	€1.2 m.
30-0124	Max = 50 t	Max = 100 t	€0.4 m.
Norreso	Max = 70 t	Max = 100 t	€0.4 m.
Rodbyhavn	Max = 80 t	Max = 100 t	€0.4 m.
3 Sisters			€5.2 m.
			€40.4 m.

O' Connor, A. & Enevoldsen, I. (2007). 'Probability based Bridge Assessment'. *ICE Journal of Bridge Engineering, Vol* 160, *No.* 3, pp. 129-137.

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Thank you for your attention

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