



SAG 7: Assessment and Interventions upon Existing Structures (AIES)

Chairs: Dr Stuart Matthews / Prof Giuseppe Mancini

Technical secretary: Prof Alberto Meda

***fib* Third Congress, Washington, 2010**

The State of the Nation 2006 - NCE July 06

Assessment of Condition of UK Infrastructure by ICE

Category	Condition Grade	Change (2005)	Sustainability Grade
Overall	C-	↑	C
Energy	D+	↑	D
Waste Management	C-	↑	D+
Water & Wastewater	B	↓	C+
Flood Risk Management	C	↓	B
Rail	C	–	D+
National Roads	C+	–	D
Local Transport	C	–	C-
Seaports	B-	–	C+
Airports	C+	–	D+

A = Good, B = Fair, C = Average, D = Poor, E = Bad

American Infrastructure Report Card by American Society of Civil Engineers 2005

Category	Condition Grade
Roads	D
Bridges	C
Transit	D+
Rail	C-
Aviation	D+
Power Grid	D
Drinking Water	D-
Waste Water	D-
Dams	D

A = Exceptional, B = Good, C = Mediocre, D = Poor, E = Failing



Activities of SAG 7

Scope: To define appropriate and reliable procedures to establish the safety of existing concrete structures and any associated requirements for interventions to extend the safe operation or working life of such structures

SAG7 is currently organized in four workgroups:

- Reliability and safety evaluation
- Modelling of structural performance of existing structures
- Assessment / evaluation procedures for existing structures
- Selection and implementation of interventions



SAG 7 activities are in support of CEN

- **SAG 7 technical work is in support of a proposed CEN project to introduce “Assessment of existing structures” concepts into the structural Eurocodes**
- **The structural Eurocodes:**
 - **Currently concerned only with the design of new structures**
 - **They deal with structures constructed with concrete, steel, steel-concrete composite, timber, masonry & aluminium**
 - **Future codes planned for glass and fibre reinforced polymers (FRP)**
- **CEN “Assessment of existing structures” project will start 2011**



First workshop fib SAG 7: Assessment of Existing Structures Turin, 16-17 October 2009





**First workshop fib SAG 7:
Assessment of Existing Structures
Turin, 16-17 October 2009
Programme**

Day 1:

- **participants gave 15 min. presentations**

Day 2:

- **Group discussions**



Participation in SAG7 first workshop

- **Diego Lorenzo Allaix** Politecnico di Torino
- **Carmen Andrade** Instituto Eduardo Torroja (IETcc)
- **Gabriele Bertagnoli** Politecnico di Torino
- **John Cairns** Heriot-Watt University
- **Vincenzo Carbone** Politecnico di Torino
- **Robby Caspee** Ghent University
- **Ane De Boer** Mot Infrastructures
- **Alan Fairhurst** Sellafeld Ltd
- **Paolo Franchin** La Sapienza University
- **Luca Giordano** Politecnico di Torino
- **Iunio Iervolino** Federico II University
- **Paul Jackson** Gifford Consulting
- **Javier Leon** FHECOR Consultant Engineers
- **Dan Kuchma** University of Illinois



Participation in first SAG7 workshop

- **Carlos Lara Saranche** Instituto Eduardo Torroja (IETcc)
- **Steinar Leivestad** Standards Norway
- **Giuseppe Mancini** Politecnico di Torino
- **Gaetano Manfredi** Federico II University
- **Stuart Matthews** Building Research Establishment Ltd (BRE)
- **Alberto Meda** Tor Vergata University
- **Paolo E. Pinto** La Sapienza University
- **Miguel Prieto** Instituto Eduardo Torroja (IETcc)
- **Irina Stipanovic Oslakovic** Institut Gradevinarstva Hrvatske (IGH)
- **Francesco Tondolo** Politecnico di Torino
- **Tamon Ueda** Hokkaido University
- **Konrad Zilch** TU Munchen
- **Corresponding participants**
- **Chris Hendy** Atkins

27 No



Workshop Day 1: Presentations at first SAG7 workshop - 1

- **S.L. Matthews:** Observations on some currently available guidance on the appraisal of existing structures
- **T. Ueda:** JCI-KCI guidelines on performance assessment of existing structures and example for concrete structure with frost damage
- **A. Fairhurst:** Structural assessment under revised criteria and condition
- **A. Meda, Z. Rinaldi:** Some considerations on the evaluation of the residual service life after the final inspection of the structure
- **P.E. Pinto, P. Franchin:** Preliminary thoughts on a safety format for assessment of existing structures
- **J. Cairns:** Residual capacity of corrosion damaged structures



Workshop Day 1: Presentations at first SAG7 workshop - 2

- **D.L. Allaix, V.I. Carbone, G. Mancini:** Probabilistic aspects of the assessment of existing concrete structures
- **R. Caspeele, L. Taerwe:** Practical application of Bayesian methods for evaluating concrete structures, including the use of prior information
- **P. Tanner, C. Lara, M. Prieto:** Development of semi-probabilistic models for the assessment of deteriorated structures
- **J. Rodriguez, L.M. Ortega, C. Andrade, D. Izquierdo:** Manual CONTECVET: Structural assessment methodology for residual life calculation of corroding concrete structures
- **L. Giordano, G. Mancini, F. Tondolo:** Combined effect of loading and corrosion in concrete structures
- **H. Corres-Peiretti, J. León:** Structure's history and life cycle



Workshop Day 1: Presentations at first SAG7 workshop - 3

- **G. Manfredi, I. Iervolino, F. Jalayer, L. Elefante:** Revisiting formats for seismic safety assessment of existing RC structures
- **D. Kuchma:** Validation of non-linear computational tools for use in practice
- **I. Stipanovic Oslakovic, S. Skaric Palic:** Analysis of durability and life cycle costing of different repair methods applied on 11 city overpasses
- **C. Andrade, I. Martinez:** Methodology for assessing and selecting repair systems
- **A. de Boer:** How to come to an acceptable unity check index for an existing structure in infrastructure
- **C. R Hendy:** Recommendations for assessment Eurocodes for bridges

18 No



Day 2: Topic areas discussed

- **Reliability and safety format**
- **Performance of structures**
- **Modelling of structural performance – no deterioration**
- **Modelling of structural performance – with deterioration**
- **Performance of repaired structures**
- **Assessment of existing structures**

Day 2 Group Discussions

- **Reliability and safety format**
- **Modelling of structural performance – with / without deterioration**
- **Performance and assessment of existing structures**



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SAG 7: Terms of reference - 1

To define, through a series of documents, the processes to be used for the assessment of present structural performance and the prediction of future structural performance of existing structures with or without damage and / or revised operational requirements, together with any associated interventions required to extend their service life. It is envisaged that the documents to be produced could include reviews of the state of the art and technical history / evolution, technical specifications and recommendations; leading to the preparation of a fib model code



SAG 7: Terms of reference - 2

- **Defining appropriate and reliable procedures for (a) the assessment of the actual structural performance of existing structures and (b) to predict the evolution of actual structural performance with time.**
- **Identifying methods for selecting appropriate interventions required to preserve or establish the desired safety level or to extend the service life of the structures concerned.**
- **Consideration is to be given to (a) structures which have / have not experienced structural deterioration / damage and (b) where the operational requirements have been modified, potentially requiring enhanced structural capacity.**
- **A progressive and targeted approach should be adopted for structural assessment procedures**



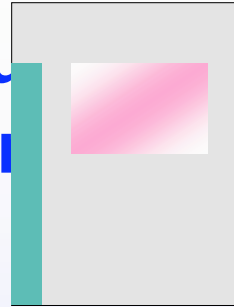
Meetings and activities of SAG7

- **First workshop in Torino, Italy: 16-17 October 2009**
- **Second meeting Washington, USA: 27-28 May 2010**
- **Third meeting Ghent, Belgium 4 & 5 Nov 2010**
- **Joint fib-RILEM workshop: 22 & 23 Nov 2010**
- **Mini-symposium on probabilistic methods for AES:
in association with ICASP11: Aug 2011**



Some guides relevant to the assessment of existing concrete structures

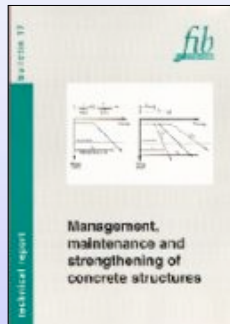
► fib Bulletins



Bulletin n°24: Seismic assessment and retrofit of reinforced concrete buildings



Bulletin n°10: Bond of reinforcement in concrete



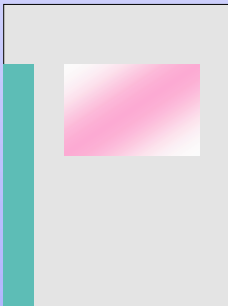
Bulletin n°17: Management and strengthening of concrete structures



Bulletin n°22: Monitoring and safety evaluation of existing concrete structures



Bulletin n°26: Influence of material and processing on stress corrosion cracking of prestressing steel - case studies



Bulletin n°xx: Condition control and assessment of reinforced concrete structures exposed to corrosive environments [Probabilistic approach]



Bulletin n°34: Model Code for Service Life Design



Bulletin n°44: Concrete structure management: Guide to ownership and good practice



Bulletin n°54: Management, assessment, maintenance and repair of concrete structures



Some guidance relevant to the assessment of existing concrete structures

► fib Bulletins



Bulletin n°10: Bond of reinforcement in concrete



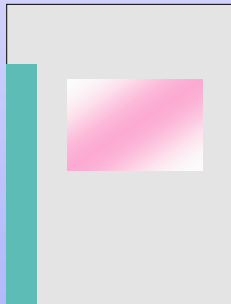
Bulletin n°17: Management and strengthening of concrete structures



Bulletin n°22: Monitoring and safety evaluation of existing concrete structures



Bulletin n°26: Influence of material and processing on stress corrosion cracking of prestressing steel - case studies



Bulletin n°xx: Condition control and assessment of reinforced concrete structures exposed to corrosive environments
[Probabilistic approach]



Bulletin n°34: Model Code for Service Life Design



Bulletin n°44: Concrete structure management:
Guide to ownership and good practice



Bulletin n°54: Management, assessment, maintenance and repair of concrete structures



Some existing guidance relevant to the assessment of existing concrete structures

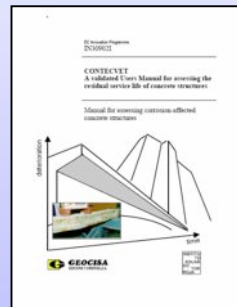
► Further Publications



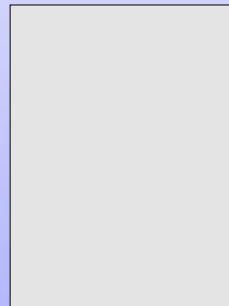
JCSS: Probabilistic assessment of existing structures



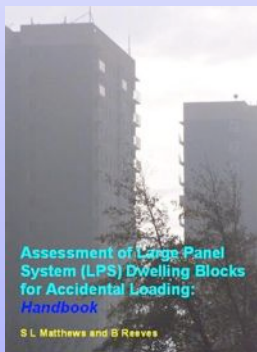
ISO 13822: Bases for design of structures-
Assessment of existing structures



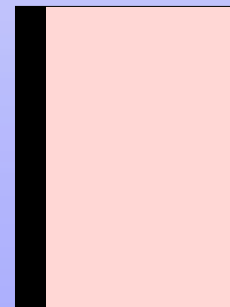
CONTECVET A validated users manual for assessing the residual service life of concrete structures



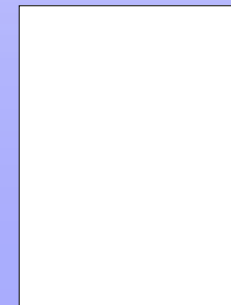
Swiss Codes SIA 269-1 to 8: Assessment of existing structures



Assessment of Large Panel System (LPS) Dwelling Blocks for Accidental Loading: Handbook



Institution of Structural Engineers:
Assessment of existing structures
1st edition 1980; 3rd edition 2010



And many more guides



Other guidance / project material

- **LIFECON project: Life cycle management of concrete infrastructures for improved sustainability**
- **NORECON project: Repair and maintenance of concrete structures**
- **CONREPNET project: Achieving durable repaired concrete structures - Adopting a performance-based intervention strategy**
- **CBDG: Guidance on the assessment of concrete bridges**
- **Sustainable Bridges project: Sustainable bridges – Assessment for future traffic demands and longer lives**
- **BRE Report: Handbook on the assessment of large panel system dwelling blocks for accidental loading**

Washington
2010, May 27

fib: SAG 7

Assessment and Interventions Upon Existing Structures

Some technical issues

*Prof. Ing. Giuseppe Mancini
Politecnico di Torino - Italy*

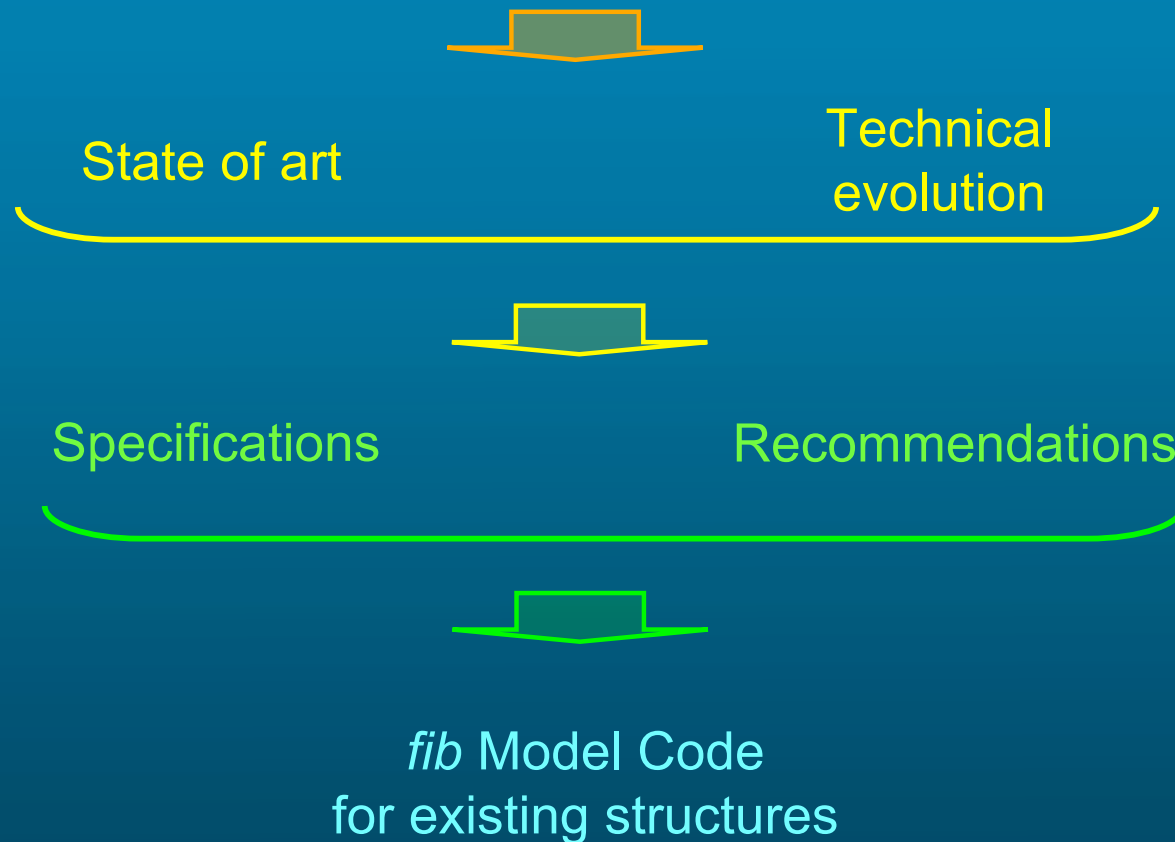
Scope of work (1)

Define appropriate
and reliable
procedures to
establish the safety
of existing
structures

Define the
necessary
requirements for
interventions to
extend the safe
operation of the
working life of
existing structures

Scope of work (2)

Documents to be produced including



Four operational Working Groups

Reliability
and safety
evaluation

Structural
performance
modeling of
existing
structures

Assessment
and
evaluation
procedure for
existing
structures

Selection and
implementation
of interventions

Reliability and safety evaluation (1)

New probabilistic approach for the definition of the safety format, able to take into account:

- Higher cost to increase safety levels in existing than in new one structures
- +
- Actual code provisions fulfilment sometime very expensive or impossible



Lower safety level acceptable under certain circumstances

Reliability and safety evaluation (2)

- Residual expected lifetime reduced respect to new structures (50/100 years)



- Consequent reduction of representative values of actions
- Durability requirements reduced or released

Reliability and safety evaluation (3)

- Reduction of uncertainties related to both:
 - Geometrical and materials parameters
 - Structural behavior in presence of a significant set of load cases and related combinations

Reliability and safety evaluation (4)

Recent studies (2010) on this subject
(Vrouwenvelder, Scholten) are proposing:

- A reduction of β values:

$$\beta_{\text{exist}} = \beta_{\text{new}} - \Delta\beta$$

$$\Delta\beta \cong 1.5$$

Limitations for human safety
criterion (constant annual
failure probability)

Reliability and safety evaluation (5)

Consequences class	Minimum reference period for existing building (years)	β -NEW		β -EXISTING	
		wn	wd	wn	wd
0	1	3,3	2,3	1,8	0,8
1	15	3,3	2,3	1,8*	1,1*
2	15	3,8	2,8	2,5*	2,5*
3	15	4,3	3,3	3,3*	3,3*

Class 0: as class 1, but no human safety involved.

wn = wind not dominant; wd = wind dominant.

*in this case is the minimum limit for human safety normative.

Table 1: Minimum values for the reliability index β with a minimum reference

Reliability and safety evaluation (6)

Consequent reduction of load factors for existing structures

	NEW		EXISTING		
	Permanent unfavourable	Variable	Permanent unfavourable	Wind	Others
STR/GEO (6.10a)					
CC 1	1,20	1,35 Ψ_0	1,10	1,10 Ψ_0	1,00 Ψ_0
CC 2	1,35	1,50 Ψ_0	1,20	1,30 Ψ_0	1,15 Ψ_0
CC 3	1,50	1,65 Ψ_0	1,30	1,50 Ψ_0	1,30 Ψ_0
STR/GEO (6.10b)					
CC 1	1,10	1,35*	1,00	1,10*	1,00*
CC 2	1,20	1,50*	1,10	1,30*	1,15*
CC 3	1,30	1,65*	1,20	1,50*	1,30*

*if not dominant, multiply with Ψ_0 .

Table 2: Load factors for the ultimate limit state

Structural performance modeling of existing structures (1)



Evaluation of
material parameters



Experimental tests integrated by “a priori knowledge” with
a Bayesian approach

Structural performance modeling of existing structures (2)

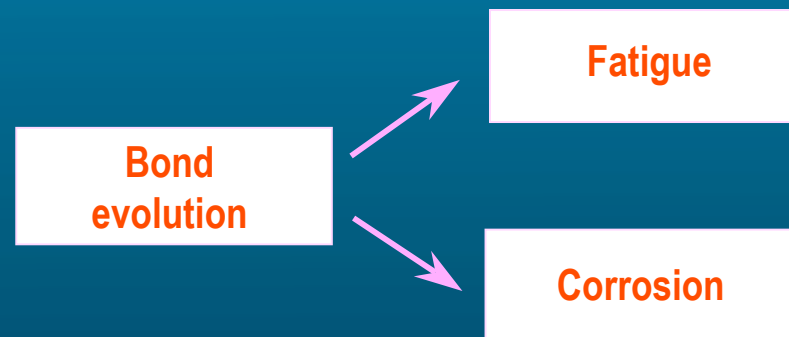


- On the overall structure numerical simulations with N.L. analyses and sensitivity analyses on the parameters having a significant influence on the results
- Integration of structural knowledge by means of “a later” informations derived by load tests on the structure finalized to the numerical model updating

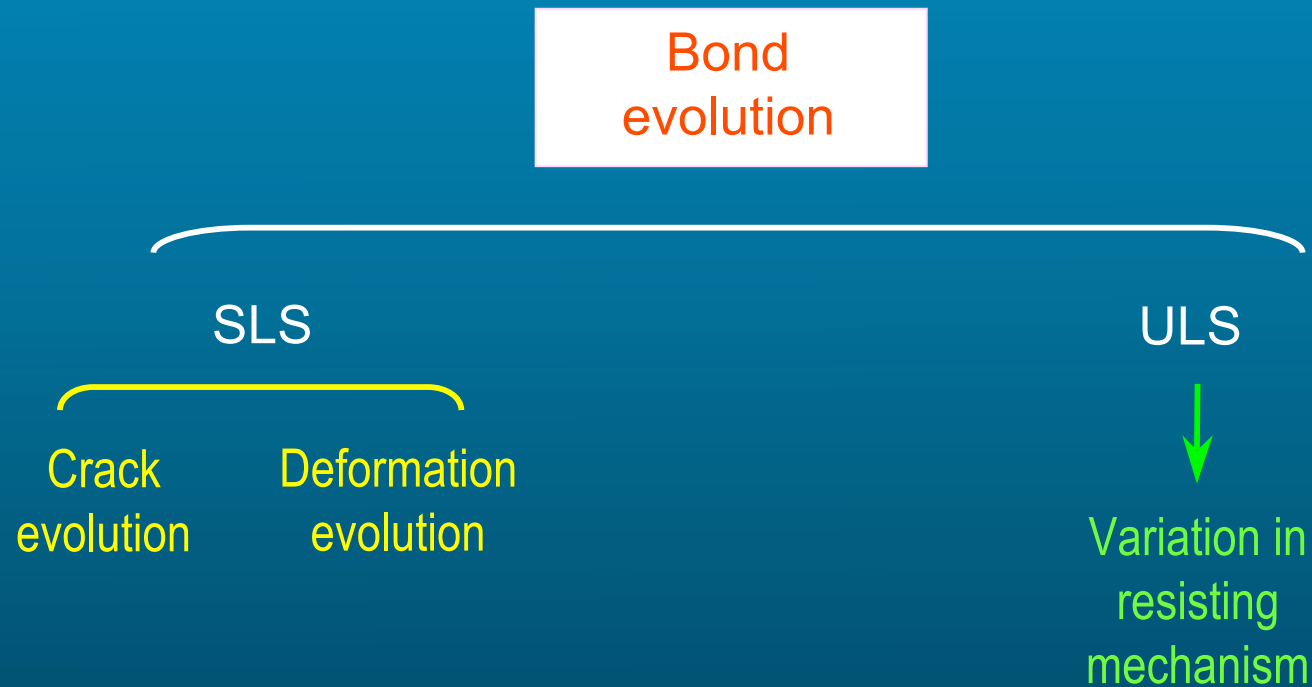
Structural performance modeling of existing structures (3)

- Definition of resisting models in existing structures and their expected evolution in time

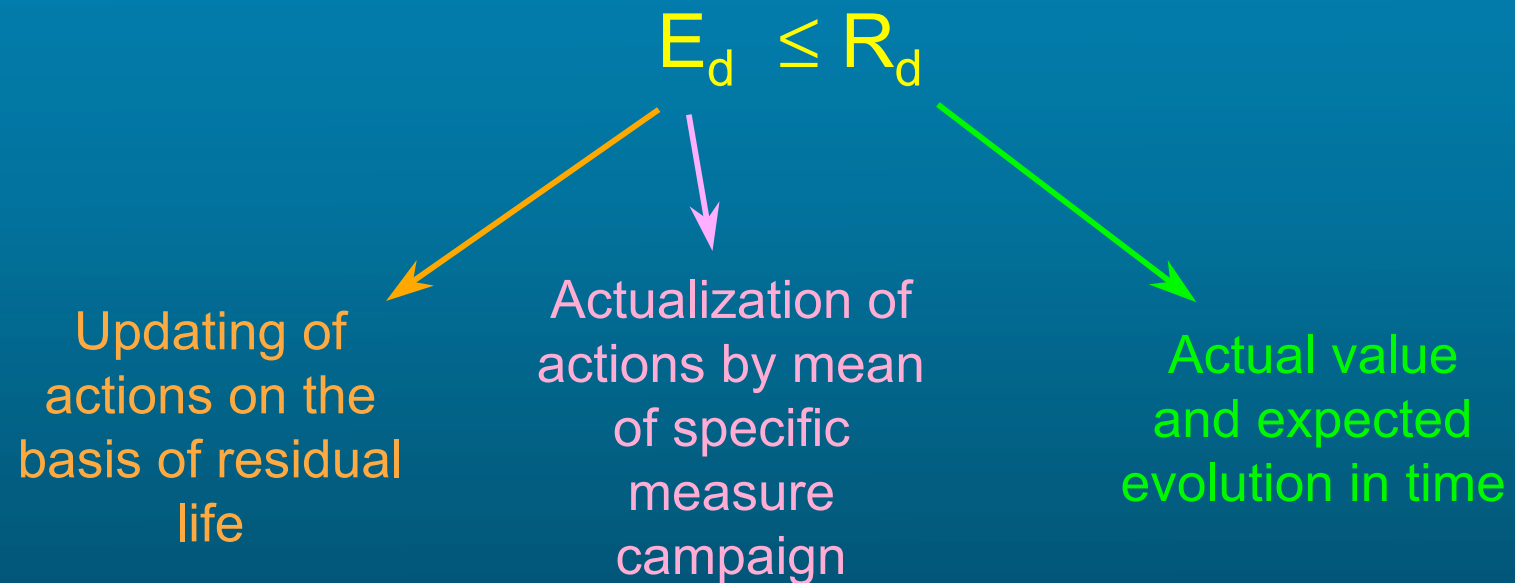
For instance:



Structural performance modeling of existing structures (4)



Assessment/evaluation procedure for existing structures (1)



Assessment/evaluation procedure for existing structures (2)

- Actual safety level
- Estimation of residual life or evolution in time of actual safety level
- Definition of measures necessary to extend the service life



- Strengthening
- Upgrading
-



Limitations to the
operability

Selections and implementation of interventions (1)



Definition of a set of interventions suitable
for the specific scope



Modeling of interventions (interface problems)

Selections and implementation of interventions (2)

- Evaluation of new resisting performance
- Feedback on the overall structure
- New reliability target after intervention

Examples



Washington
2010, May 27



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Fatigue test



Static test

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Thanks for Listening

We wish to acknowledge the contributions made by the members of SAG7. We thank them for their efforts and support so far.