TU1406
COST ACTION

WG MEETINGS & WORKSHOP
An overview of Key Performance Indicators across Europe and Overseas
The main findings from WG1 and other contributions from WG2 and WG3

LIFECYCLE-BASED DISCRETIZATION OF BRIDGE PERFORMANCE INDICATORS

Dimosthenis Kifokeris – Ph.D. candidate, Aristotle University of Thessaloniki,
Faculty of Engineering, School of Civil Engineering, Greece

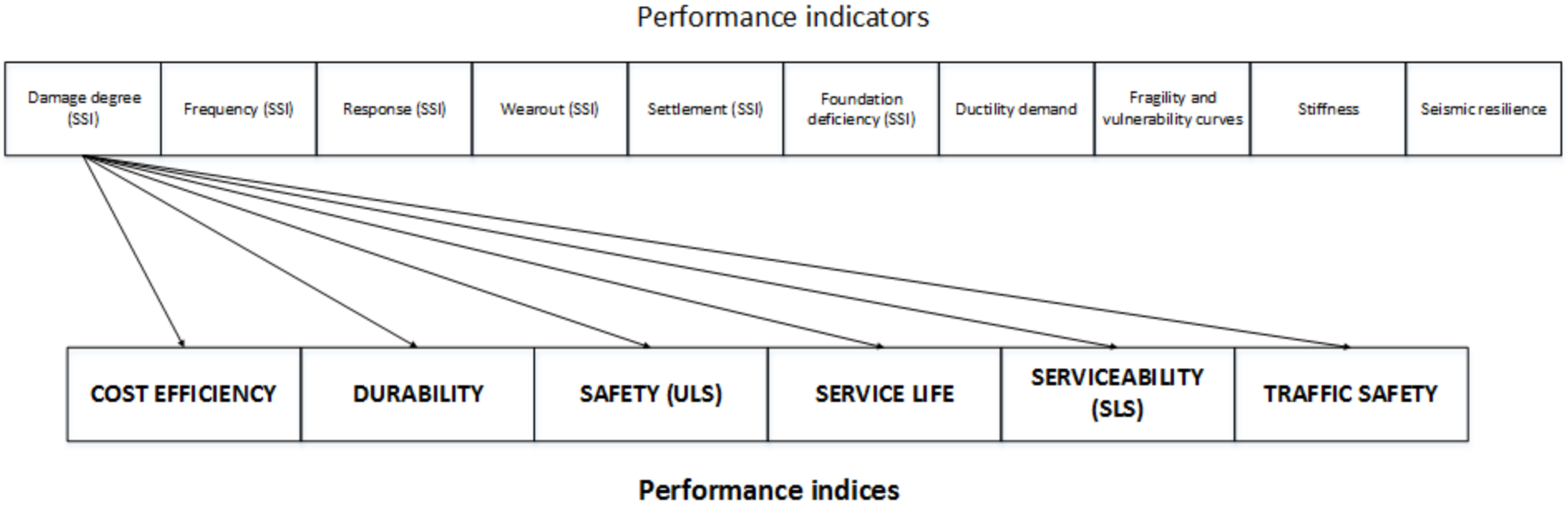
30th March - 1st April 2016
Belgrade, Serbia

BRIDGE PERFORMANCE INDICATORS (BPIs)

- Damage degree, frequency, response, wearout, settlement and foundation deficiency of the constituent bridge parts due to SSI (soil-structure interaction) during ground motions
- Ductility demand
- Fragility and vulnerability curves, most often interconnected
- Stiffness
- Seismic resilience

The above were the results of a targeted and filtered literature review of the recent (2006-2016) Greek research output

BRIDGE PERFORMANCE INDICATORS (BPIs)



All BPIs were aggregately researched under the light of the above performance indices categories. Hence, each one is simultaneously part of every indices group.

LIFECYCLE MANAGEMENT DETERMINANTS

- Project performance: the level of the desirable success in meeting the stated technical performance specifications and the mission to be performed
- Success determinants of project performance:

  (i) Cost of completion

  (ii) Time of completion

  (iii) Quality of deliverables
- Additional determinants (considered separately or as aspects of the quality of the deliverables): safety, client satisfaction etc.

LIFECYCLE MANAGEMENT RELATED NOTIONS

- **Constructability**: the optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve overall project objectives
- **Sustainability**: the promotion of the development that meets the needs of the present without compromising the ability of future generations to achieve their own
- **Risk analysis**: the collective methodology of risk assessment, through a systematic process of decision-making in order to accept a known or assumed risk and/or reducing the harmful consequences or probability of occurrence of the risk

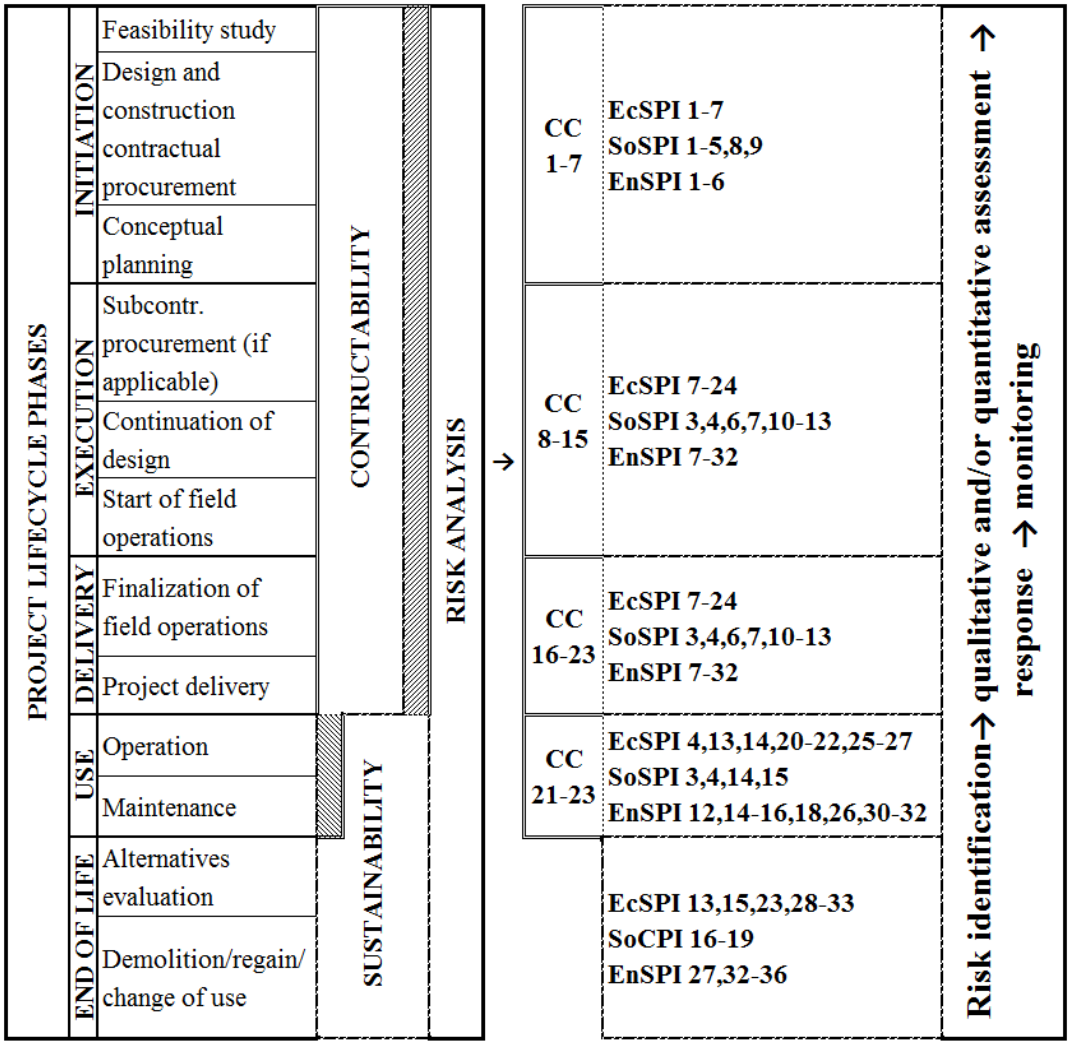
RELATED NOTIONS AND LIFECYCLE MANAGEMENT

Constructability, sustainability and risk analysis, separately and in combination, aim for the achievement of the highest level of project performance by optimizing the success determinants.

Each utilizes distinct cognitive, methodological and mathematical tools and applications.

For a holistic lifecycle management, from the feasibility study of a project until its end of life, all three should be integrated, interconnected and facilitated.

HOLISTIC LIFECYCLE MANAGEMENT



- **Constructability**

  - implemented through 23 Constructability Concepts (CCs)
  - pertains mainly the initiation, execution and delivery phases
  - extends in the use phase

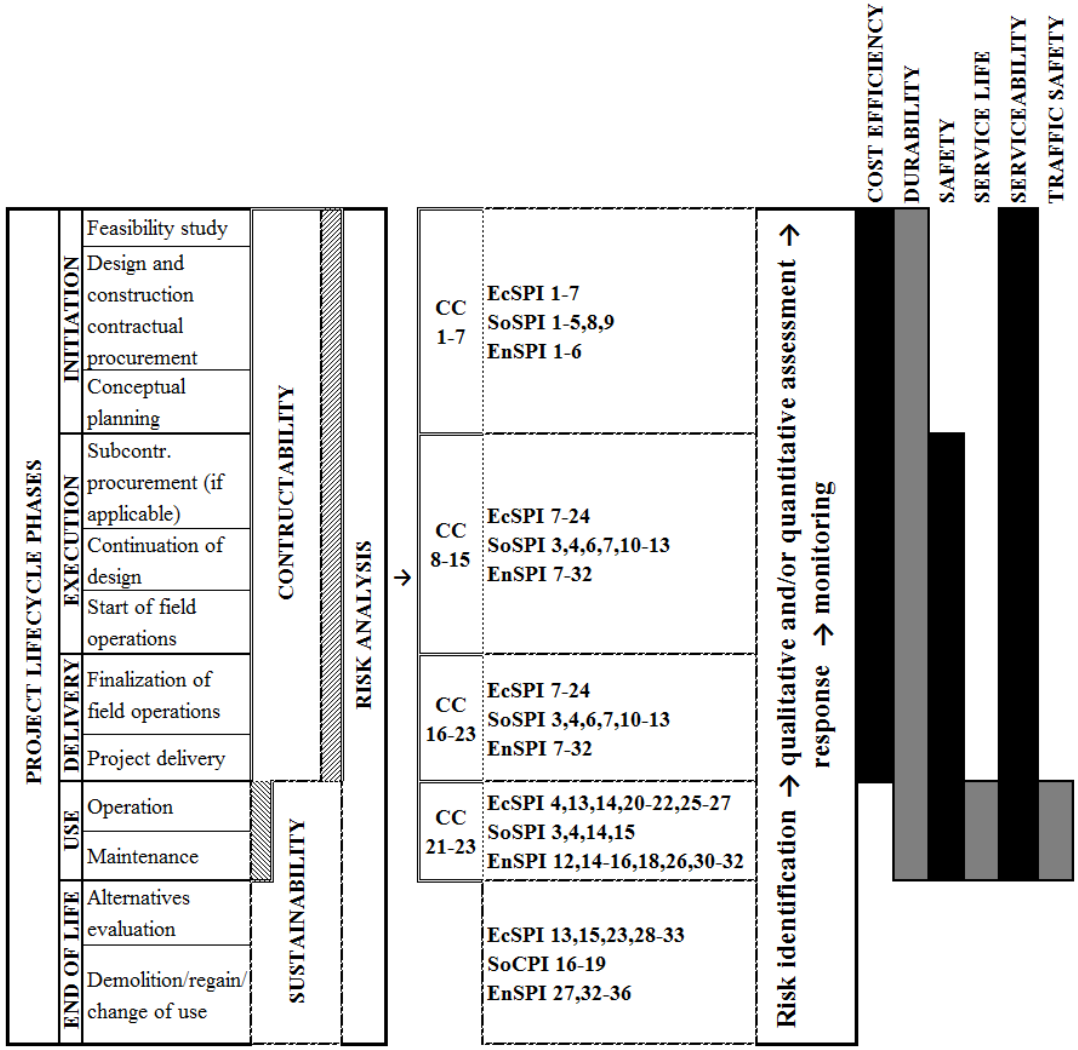
- **Sustainability**

  - implemented through 32 economic (EcSPI), 19 social (SoSPI) and 36 environmental (EnSPI) sustainability performance indicators
  - pertains all of the project lifecycle, but more heavily the use and end-of-life phases

- **Risk analysis**

  - performed through risk identification, qualitative and/or quantitative assessment, response and monitoring
  - pertains all of the project lifecycle

LIFECYCLE DISCRETIZATION OF BPIs



- Each index encompasses all the noted BPIs
- All BPIs should be checked for the corresponding lifecycle phases pertained by the index and in conjunction with the CCs and SPIs
- Where the indices overlap, the corresponding BPIs should be multiply checked under the light of every index

CONCLUSIONS

- In the recent literature originating from Greek researchers, the most commonly researched BPIs account mainly for the cost efficiency, durability, safety, service life, serviceability and traffic safety of a bridge
- A true holistic lifecycle management plan for bridges should incorporate, interconnect and integrate the distinctive BPIs, grouped under the corresponding performance indices, along with the SPIs, CCs and risk analysis procedures
- The discretization and integration of BPIs, SPIs and CCs could expand to cover more data and also include several types of new indicators, towards the production of a general approach for enhanced lifecycle management for bridges and the standardization of bridge quality standards at the European level

REFERENCES

[1] Anton De Wit, editor. Measuring project success: an illusion. Project Management Institute, Montreal, Canada, 1986.

[2] Anastasios Kotsoglou and Stavroula Pantazopoulou. Response simulation and seismic assessment of way overcrossings. Earthquake Engineering and Structural Dynamics, 39:991-1013, 2010.

[3] Anastasios G. Sextos, George E. Mylonakis and Elli-Konstantina V. Mylona. Rotational excitation of bridges supported on pile groups in soft or liquefiable soil deposits. Computers and Structures, 155: 54-66, 2015.

[4] Anastasios Sextos, Periklis Faraonis, Costas Papadimitriou and Panagiotis Panetsos. System identification of a R/C bridge based on ambient vibrations and 3D numerical simulations of the entire soil-structure system. In COMPDYN 2011, 3rd ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, Corfu, Greece, 25-28 May 2011.

[5] Andreas J. Kappos, M. Saiid Saiidi, M. Nuay Aydinoglu and Tatjana Isakovic, editors. Seismic design and assessment of bridges. Springer Science and Business Media Dordrecht, Dordrecht, The Netherlands, 2012.

[6] Construction Industry Institute (CII). Constructability: a primer. CII, The University of Texas at Austin, Austin, U.S.A., 1986.

[7] Christos Katsaras, Telemachos B. Panagiotakos, Basil Kolias. Effect of torsional stiffness of prestressed concrete box girders and uplift of abutment bearings on seismic performance of bridges. Bull Earthquake Engineering, 7:363-375, 2009.

[8] Demos C. Angelides. Project management and good technical and business practices. Journal of Management in Engineering, 15(3):78-88, 1999.

[9] Dimitrios Timosidis and Stavroula J. Pantazopoulou. Limit state model for R.C. bridge joints under seismic loading. Bull Earthquake Engineering, 5:391-423, 2007.

[10] Dimosthenis Kifokeris and Yiannis Xenidis.Towards the combination of risk analysis, constructability and sustainability for the lifecycle management of construction projects. In IALCCE '16 Fifth International Symposium on Life-Cycle Civil Engineering, forthcoming in 2016.

[11] George C. Manos, Konstantinos Katakalos and Vladimiros Kourtides. Cyclic behavior of a hybrid anchoring device enhancing the flexural capacity and ductility of an R/C bridge-type pier strengthened with CFRP sheets. Journal of Civil Engineering Research, 3(1):52-63, 2013.

[12] George C. Manos, Vladimiros Kourtides and Anastasios Sextos. Model bridge pier-foundation-soil interaction implementing in-situ / shear stack testing and numerical simulation. In The 14th World Conference on Earthquake Engineering, Beijing, China, 12-17 October 2008.

[13] Georgios Tsionis and Michael N. Fardis. Seismic fragility of concrete bridges with deck monolithically connected to the piers or supported on elastomeric bearings. In 15th World Conference on Earthquake Engineering, Lisbon, Portugal, 24-28 September 2012.

[14] Ioannis F. Moschonas and Andreas J. Kappos. Assessment of concrete bridges subjected to ground motion with an arbitrary angle of incidence: static and dynamic approach. Bull Earthquake Engineering, 11:581-605, 2013.

[15] Ioannis F. Moschonas, Andreas J. Kappos, Panagiotis Panetsos, Vissarion Papadopoulos, Triantafyllos Makarios and Panos Thanopoulos. Seismic fragility curves for Greek bridges: methodology and case studies. Bull Earthquake Engineering, 7:439-468, 2009.

[16] Li-Yin Shen, Jian Li Hao, Vivian Wing-Yian Tam and Hong Yao. A checklist for assessing sustainability performance of construction projects. Journal of Civil Engineering and Management, 13(4):273-281, 2007.

[17] Mekdam A. Nima. Constructability factors in the Malaysian construction industry. Ph.D. thesis, University Putra Malaysia, Putrajaya, Selangor, Malaysia, 2001.

[18] Michael N. Fardis and Georgios Tsionis. Eigenvalues and modes of distributed-mass symmetric multispan bridges with restrained ends for seismic response analysis. Engineering Structures, 52:141-149, 2013.

[19] Nikolaos Lesgidis, Oh-Sung Kwon and Anastasios Sextos. A time-domain seismic SSI analysis method for inelastic bridge structures through the use of a frequency-dependent lumped parameter model. Earthquake Engineering & Structural Dynamics, 44:2137-2156, 2015.

[20] Olympia Taskari and Anastasios Sextos. Multi-angle, multi-damage fragility curves for seismic assessment of bridges. Earthquake Engineering & Structural Dynamics, 44:2281-2301, 2015.

[21] Olympia Taskari and Anastasios Sextos. Probabilistic assessment of abutment-embankment stiffness and implications in the predicted performance of short bridges. Journal of Earthquake Engineering, 19:822-846, 2015.

[22] Patrick T. I. Lam and Franky W. H. Wong. Improving building project performance: how buildability benchmarking can help. Construction Management and Economics, 27(1): 41-52, 2009.

[23] Philip B. Crosby, editor. Quality is free. McGraw-Hill, New York, U.S.A., 1979.

[24] Stylianos Farantakis, Anastasios Kotsoglou and Stavroula Pantazopoulou. Exploiting SSI to mitigate seismic demands in bridge piers. In Tenth U.S. National Conference on Earthquake Engineering – Frontiers of Earthquake Engineering , Anchorage, Alaska, July 21-25 2014.

[25] Stergios A. Mitoulis, Magda D. Titirla and Ioannis A. Tegos. A new earthquake resistant abutment as means to reduce the seismic demand ofa railway bridge. In 15th World Conference on Earthquake Engineering, Lisbon, Portugal, 24-28 September 2012.

[26] Sevasti D. Tegou, Stergios A. Mitoulis and Ioannis A. Tegos.An unconventional earthquake resistant abutment with transversely directed R/C walls. Engineering Structures, 32:3801-3816, 2010.

[27] Stergios A. Mitoulis and Ioannis A. Tegos.An unconventional restraining system for limiting the seismic movements of isolated bridges. Engineering Structures, 32:1100-1112, 2010.

[28] Themelina S. Paraskeva, Andreas J. Kappos and Anastasios G. Sextos. Extension of modal pushover analysis to seismic assessment of bridges. Earthquake Engineering and Structural Dynamics, 35:1269-1293, 2006.

[29] Vijay P. Singh, Sharad K. Jain and Aditya Tyagi. Risk and reliability analysis: a handbook for Civil and Environmental Engineers. The American Society of Civil Engineers (ASCE) Publications, Reston, U.S.A., 2007.

[30] Vasileios G. Pilitsis, Vassilis K. Papanikolaou, Ioannis A. Tegos and Kosmas-Athanasios Stylianidis. A novel mechanism for restraining seismic actions in ductile bridges: analytical modeling and experimental verification. In COMPDYN 2015, 5thECCOMAS Thematic Conference on [31] Computational Methods in Structural Dynamics and Earthquake Engineering, Crete Island, Greece, 25-27 May 2015.

[31] Vasilios G. Bardakis and Michael N. Fardis. Nonlinear dynamic v elastic analysis for seismic deformation demands ncrete bridges having deck integral with the piers. Bull Earthquake Engineering, 9:519-535, 2011.

[32] Vassilis K. Papanikolaou and Andreas J. Kappos. Numerical study of confinement effectiveness in solid and hollow reinforced concrete bridge piers: Methodology. Computers and Structures, 87:1427-1439, 2009a.

[33] Vassilis K. Papanikolaou and Andreas J. Kappos. Numerical study of confinement effectiveness in solid and hollow reinforced concrete bridge piers: Analysis results and discussion. Computers and Structures, 87:1440-1450, 2009b.

[34] World Commission on Environment and Development (WCED).Our Common Future (Brundtland Report).Oxford University Press, New York, U.S.A., 1987.

TU1406
COST ACTION

THANK YOU FOR YOUR ATTENTION!

WWW.TU1406.EU