IM-SAFE.EU

IM-SAFE (ref. 958171)

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Introducción y presentación del proyecto IM-SAFE y sus objetivos

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IM-SAFE Contexto

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IM-SAFE Contexto

Los **riesgos** de **seguridad** se han vuelto críticos en los últimos años

El **mantenimiento óptimo** solo es posible si se basa en **datos** de **monitorización**

La **estandarización** en **monitorización** y **mantenimiento** es clave

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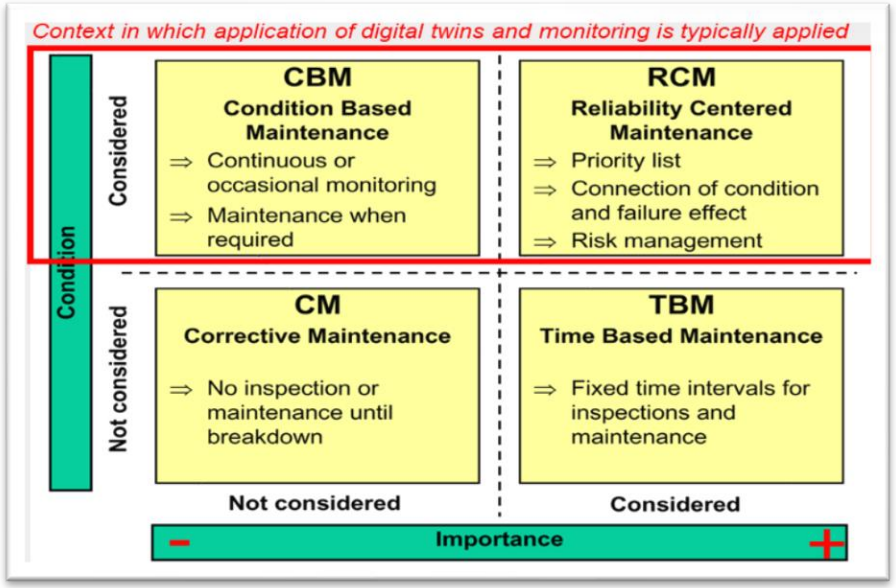
IM-SAFE El proyecto

alcance

reto

- ✓ Apoyar a CE y a CEN en la elaboración de nueva normativa sobre monitorización
- ✓ Recoger la contribución de autoridades públicas y del sector

objetivos



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IM-SAFE Resultados

Manifiesto para apoyar a CEN

- mejoras de la normativa europea existente sobre **evaluación de la seguridad**
- nueva normativa sobre **monitorización estructural**
- nueva normativa para el **mantenimiento** de las infraestructuras de transporte basado **datos (condition-based and risk-based)**

Punto de partida

- revisión de la **normativa europea**
- identificación de **barreras PEST** y **estado de la práctica** actual en mantenimiento
- análisis de **tendencias**
- evaluación de **necesidades de estandarización** para habilitar soluciones digitales

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Resultados preliminares del análisis normativo del proyecto IM-SAFE

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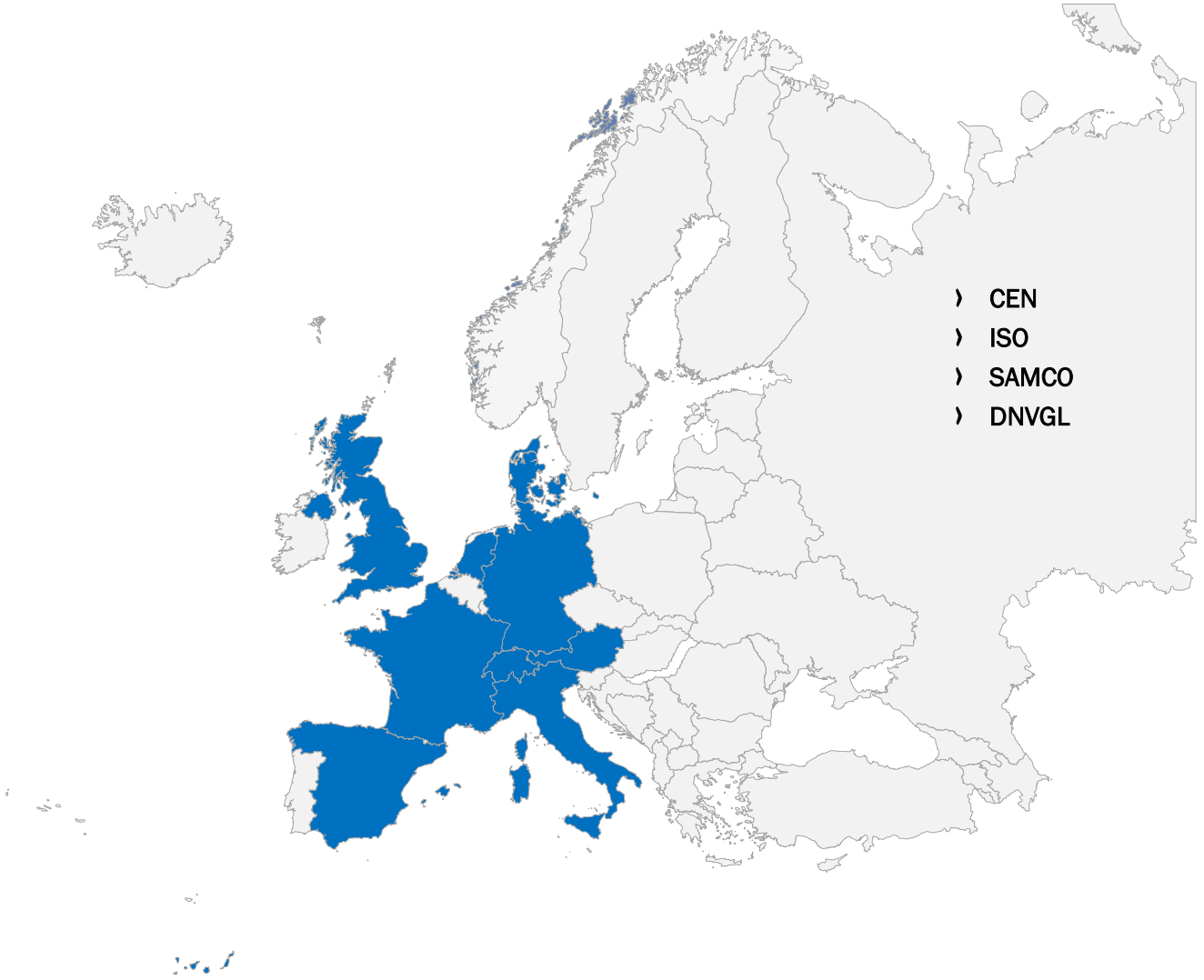
IM-SAFE Estado actual de la estandarización (análisis en curso)



>10
Países

>60
Normas y reglamentos

3
Líneas de estandarización

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IM-SAFE Normativa monitorización estructural (en curso)

01 Definición de monitorización
- Sensores
- Observación continua o periódica
- NA

02 Objetivos de la monitorización
- Identificación de daños
- Evaluación de la seguridad
- Control estructural en operación
- Dato para planificación del mto.

03 Frecuencia de monitorización
- Temporal
- Periódica
- Continua

04 Otros
- Campo de aplicación
- Indicación de la precisión de medida
- Elemento físico medido
- Adquisición, depuración y procesamiento de datos

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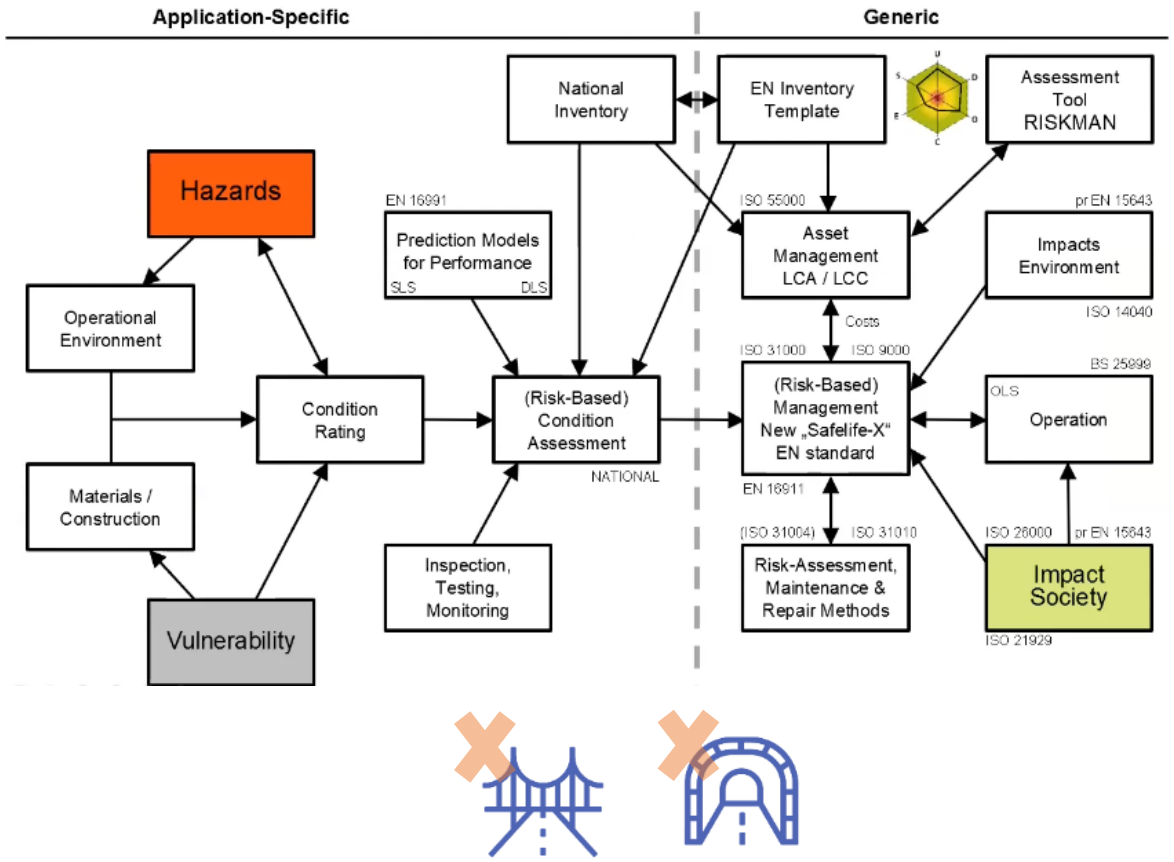
IM-SAFE Normativa mantenimiento condition-based & risk-based

(en curso)



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IM-SAFE Normativa mantenimiento condition-based & risk-based

(en curso)

01

Similaridad de pasos:
- **Determinación de elementos**
- **Inspecciones y clasificación de daños**
- **Valoración preliminar**
- **Valoración detallada e intervenciones**

02

Menos normativa para túneles disponible

03

IT- Mención a la evaluación de la resiliencia del sistema

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IM-SAFE Normativa evaluación de la seguridad basada en datos

(en curso)

01 CEN está preparando nueva normativa

02 Niveles de evaluación:
- Evaluación preliminar
- Evaluación detallada

03 Niveles de fiablilidad:
- Mismo nivel que en diseño
- Menor nivelque en diseño
- No especificado

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Mesa redonda

Reflexiones sobre normativa en monitorización y mantenimiento de infraestructuras y su futuro

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MESA REDONDA invitados

José Conrado
ADIF

Pedro Arias
Universidad de Vigo

Ignacio Jardí
Railway Innovation Hub

Diego Zamora
Tecnalia

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IM-SAFE Próximos pasos

IM-SAFE

- Talleres en otras geografías europeas
- Primeras conversaciones con EC y CEN
- Foro IM-SAFE paneuropeo
- Recogida y análisis de información: prácticas actuales, normativa, tendencias, barreras PEST, case studies

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TÚ

- www.IM-safe-project.eu https://www.linkedin.com/company/im-safe-project/
  - Información sobre entregables y eventos
- Recibirás la presentación de hoy. Contesta a scuerva@ferrovial.com si estás interesado en seguir los avances del proyecto y seguir contribuyendo

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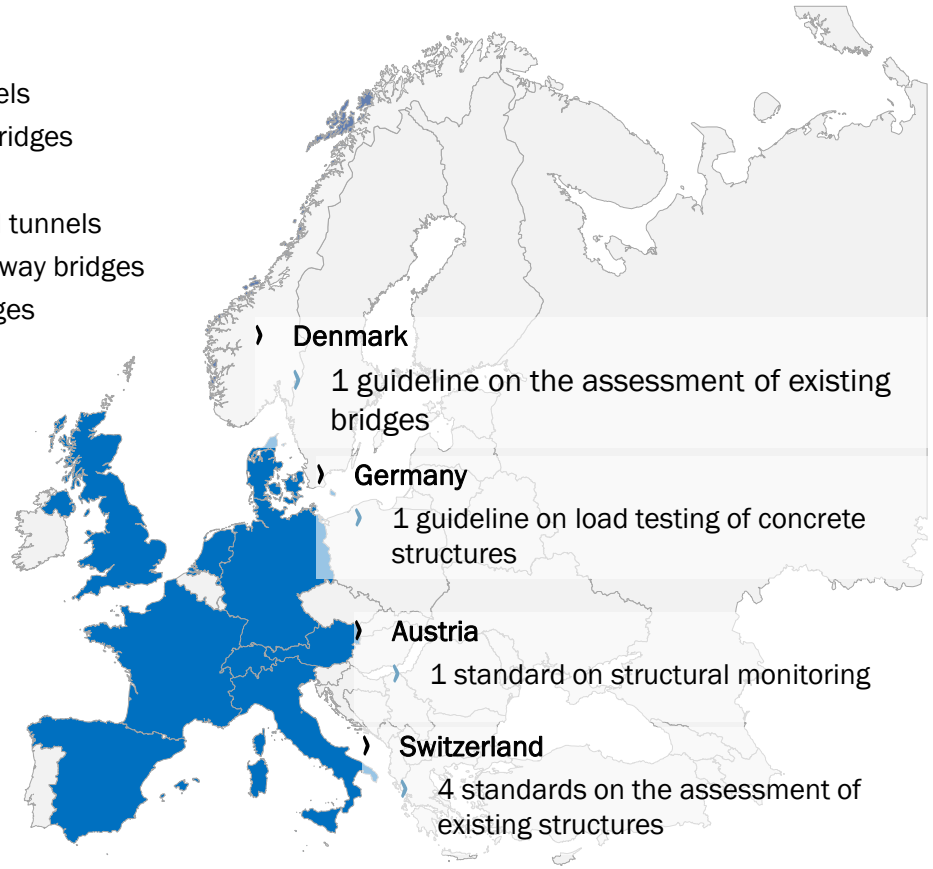
Overview of current state of standardization (ongoing)

- **UK**
  - 1 guideline on inspections of road tunnels
  - 2 guideline on inspections of highway bridges
  - 1 guideline on load testing of bridges
  - 1 guideline on the management of road tunnels
  - 6 guideline on the management of highway bridges
  - 8 guidelines on the assessment of bridges



- **Denmark**
  - 1 guideline on the assessment of existing bridges
- **Germany**
  - 1 guideline on load testing of concrete structures
- **Austria**
  - 1 standard on structural monitoring
- **Switzerland**
  - 4 standards on the assessment of existing structures

- **The Netherlands**
  - 1 guideline on inspections
  - 2 standards on the assessment of existing structures
  - 1 guideline on the assessment of existing bridges

- **France**
  - 1 guideline on load testing of bridges
  - 1 guideline on inspections of road tunnels
  - 1 information note on the safety assessment of existing bridges

- **Italy**
  - 1 guideline on structural monitoring
  - 1 guideline on risk management, safety assessment and monitoring of existing bridges

- **China**
  - 1 standard on structural monitoring
- **CEN**
  - draft versions of 2 standards on the assessment of structures
  - 2 standards on inspection and maintenance
- **ISO**
  - 2 standards on structural monitoring
  - 1 standard on the assessment of existing structures
  - 1 standard on asset management
- **SAMCO**
  - 1 guideline on structural health monitoring
  - 1 guideline on the assessment of existing structures
- **DNVGL**
  - 1 guideline on inspection planning
  - 1 guideline on sensor systems
  - 1 guideline on data-driven algorithms and models
  - 1 guideline on data quality assessment
  - 2 guidelines on risk-based verifications

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Overview of current state of standardization
Structural monitoring

- **Standards and guidelines on structural monitoring**
  - China: Technical code for monitoring of buildings and bridge structures
  - Italy: UNI/TR 11634:2016 Linee guida per il monitoraggio strutturale (Guideline for structural health monitoring)
  - Austria: RVS 13.03.01 Monitoring von brücken und anderen ingenieurbauwerken (Monitoring of bridges and other engineering structures)
  - ISO: ISO4866 Mechanical vibration and shock - Guidelines for the measurement of vibrations and evaluation of their effects on structures
  - ISO: ISO14963 Mechanical vibration and shock - Guidelines for dynamic tests and investigations on bridges and viaducts
  - SAMCO: Guideline for Structural Health Monitoring

- **Standards and guidelines with provisions about structural monitoring**
  - UK: CS 470 Management of sub-standard highway structures
  - UK: CS 464 Non-destructive testing of highways structures

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Overview of current state of standardization

Structural monitoring

Country / Standardisation body	Standard / guideline	Definition of monitoring
	Technical code for monitoring of buildings and bridge structures	Frequent, continuous observation or measurement of the state of the structure
	UNI/TR 11634:2016 Linee guida per il monitoraggio strutturale (Guideline for structural health monitoring)	Detection of the condition or behaviour of a structure and its evolution over time through instrumental acquired measurements by means of sensors
	RVS 13.03.01 Monitoring von brücken und anderen ingenieurbauwerken (Monitoring of bridges and other engineering structures)	Non-destructive, measured value-based automated investigation and control of engineering structures
	ISO4866 Mechanical vibration and shock - Guidelines for the measurement of vibrations and evaluation of their effects on structures	Not given
	ISO14963 Mechanical vibration and shock - Guidelines for dynamic tests and investigations on bridges and viaducts	Not given
	Guideline for Structural Health Monitoring	During condition monitoring of structures global and local structural properties are evaluated based on continuously measured values
	CS 470 Management of sub-standard highway structures	The periodic or continuous observation and recording of information pertaining to structural behaviour
	CS 464 Non-destructive testing of highways structures	**Global** monitoring: acoustic emission monitoring technique to identify the presence of active defects in a structure with a minimum number of sensors over long distances **Local** monitoring: Acoustic emission monitoring technique to provide detailed information on source location, orientation and on the characteristics of defects and failure.

Overview of current state of standardization

Structural monitoring

Country / Standardisation body	Standard / guideline	Goal of monitoring	Monitoring types
	Technical code for monitoring of buildings and bridge structures	1) ensuring safety during construction and operation 2) structural damage identification 3) provide input for repair and maintenance	Construction / post-construction Continuous / frequent Global / local
	UNI/TR 11634:2016 Guideline for structural health monitoring	1) control of structural condition during operation 2) identification of deterioration	Continuous / periodic / temporary Global / local
	RVS 13.03.01 Monitoring of bridges and other engineering structures	1) documentation of construction stages 2) monitoring of the condition development during operation 3) early recognition of critical conditions	Continuous / periodic / temporary Global / local
	ISO4866 Mechanical vibration and shock - Guidelines for the measurement of vibrations and evaluation of their effects on structures	1) problem recognition 2) control of condition during operation 3) Assessing severity of vibrations	Continuous / periodic / temporary Global / local
	ISO14963 Mechanical vibration and shock - Guidelines for dynamic tests and investigations on bridges and viaducts	1) evaluating the safety of bridge structures under construction and during operation 2) confirming after construction the values used in design 3) monitoring of real bridges in-service and detecting any damage	Continuous / periodic / temporary Global / local
	Guideline for Structural Health Monitoring	1) improved knowledge of the current state and long-term behaviour 2) evaluation of current safety 3) input for maintenance planning	Continuous / periodic / temporary Global / local
	CS 470 Management of sub-standard highway structures	1) to detect deterioration or distress if it occurs 2) to determine the extent, severity and rate of deterioration, and to determine whether a critical limit state or other criteria are at risk of being reached	Continuous / periodic / temporary Global / local
	CS 464 Non-destructive testing of highways structures	to identify the presence of active defects in a structure	Continuous / periodic / temporary Global / local

Overview of current state of standardization

Structural monitoring

Country / Standardisation body	Standard / guideline	Field of application	Measured physical quantities	Requirements on measurement accuracy	Guidelines on data acquisition, cleansing and pre-processing	Guidelines on use of monitoring data for structural diagnostics / safety evaluation / asset management
	Technical code for monitoring of buildings and bridge structures	High-rise buidlings, long-span bridges	Loads and load effects	Yes	Yes	No
	UNI/TR 11634:2016 Guideline for structural health monitoring	Engineering structures	Loads and load effects, effects caused by physical - chemical processes	Yes	Yes	structural diagnostics
	RVS 13.03.01 Monitoring of bridges and other engineering structures	Engineering structures	Loads and load effects	No	No	structural diagnostics
	ISO4866 Mechanical vibration and shock - Guidelines for the measurement of vibrations and evaluation of their effects on structures	Engineering structures	Loads and load effects	Yes	Yes	structural diagnostics
	ISO14963 Mechanical vibration and shock - Guidelines for dynamic tests and investigations on bridges and viaducts	Bridges	Load effects	No	Yes	structural diagnostics
	Guideline for Structural Health Monitoring	Engineering structures	Loads and load effects, effects caused by physical - chemical processes	No	Yes	structural diagnostics
	CS 470 Management of sub-standard highway structures	Highway structures	Physical-chemical processes	No	No	structural diagnostics, asset management
	CS 464 Non-destructive testing of highways structures	Highway structures	Effects caused by physical-chemical processes	No	No	structural diagnostics

Overview of current state of standardization

Condition-based and risk-based maintenance

- **Standards and guidelines**
  - ISO: ISO 55000 Asset management - Overview, principles and terminology
  - ISO: ISO 31000 Risk management - Principles and guidelines
  - ISO: ISO 31004 Risk management - Guidance for the implementation of ISO 31000
  - ISO: ISO 31010 Risk management - Risk assessment techniques
  - CEN: EN 16991 Risk-based inspection framework
  - CEN: EN 15341 Maintenance - Maintenance Key Performance Indicators
  - Italy: Guidelines for risk classification and management, safety assessment and monitoring of existing bridges
  - UK: CS 462 Repair and management of deteriorated concrete highway structures
  - UK: CS 465 Management of post-tensioned concrete bridges
  - UK: CS 466 Risk management and structural assessment of concrete half-joint deck structures
  - UK: CS 467 Risk management and structural assessment of concrete deck hinge structures
  - UK: CS 470 Management of sub-standard highway structures
  - UK: CM 430 Maintenance of road tunnels

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Overview of current state of standardization

Condition-based and risk-based maintenance

Country	Standard / guideline	Steps of the decision-making process	Objective	When	Types of measures
	CS 462 Repair and management of deteriorated concrete highway structures	1) Condition survey	To gather information on the current condition	Not specified	• Reactive essential maintenance • Preventive maintenance
		2) Condition assessment (desk study)	To evaluate the current performance		
		3) Additional investigations of concrete condition	To gather additional information on the current condition in case of doubts		
		4) Structural assessment	To assess load bearing capacity based on semi-probabilistic approach		
	CS 465 Management of post-tensioned concrete bridges	1) Risk review	To identify the needs for a further risk assessment	6 years, if risk-based inpsection planning is not applied	• Inspection (incl. structural monitoring) • Assessment • Remediation (maintenance, repair, strengthening, replacement)
		2) Risk assessment	To identifiy hazards, risk events, likelihood, consequence and risk levels		
		3) Risk management	To define measures for mitigating or removing identified risks		
		4) Decision regarding prioritisation and risk management measures			
	CS 466 Risk management and structural assessment of concrete half-joint deck structures CS 467 Risk management and structural assessment of concrete deck hinge structures	1) Initial review	To assess whether the information available is 1) sufficient to enable a risk assessment to be carried out; 2) current; 3) valid	Not specified	• Inspection • Maintenance activities • Monitoring • Interim / long term measures • Investigations • Repair • Strengthening • Replacement
		2) Risk assessment for structural assessment	To prioritise half-joint structures for structural assessment		
		3) Structural review	To determine if a new structural assessment is required		
		4) Structural assessment	Assessing load bearing capacity based on semi-probabilistic approach		
		5) Risk assessment for management	To prioritise structures with half-joints for management and interventions		
		6) Management plan (decision regarding risk management measures)			

Overview of current state of standardization

Condition-based and risk-based maintenance

Country	Standard / guideline	Steps of the decision-making process	Objective	When	Types of measures
	CS 470 Management of sub-standard highway structures	1) Indentification of immediate risk structures	To identify structures that need urgent application of load mitigation measures	• The structure does not satisfy the UC • Accidental damage • Observation of adverse state during inspection	• Monitoring interim measures • Load mitigation interim measures
		2) Risk assessment	Classification of low/high risk structures		
		4) Decision regarding mitigation measures			
	CM 430 Maintenance of road tunnels	1) Risk review	To identify the needs for a further risk assessment	Not specified	• Inspection • Maintenance (corrective, planned and preventive) • Major overhaul and refurbishment • Monitoring • Testing
		2) Risk analysis	To identifiy hazards, risk events, likelihood, consequence and risk levels		
		4) Decision regarding maintenance and planning			
	Guidelines for risk classification and management, safety assessment and monitoring of existing bridges	1) Census of all structures	To determine the number of structures to be managed and their properties	Not specified	• Inspection • Maintenance activities • Monitoring • Investigations • Repair • Strengthening • Replacement
		2) Visual inspections and relief of the structure	To assess damage state		
		3) Definition of attention class	To perform risks assessment of bridges		
		4) Preliminary structural assessment	To determine if a detailed structural assessment is required		
		5) Detailed structural assessment	To identify the needs for interventions		
		6) Evaluation of network resilience			

Overview of current state of standardization

Data-informed safety assessment

- **Standards and guidelines**
  - ISO: ISO 13822: Bases for design of structures — Assessment of existing structures
  - CEN: prEN1990-2: Eurocode - Basis of assessment and retrofitting of existing structures: general rules and actions
  - CEN: prEN1992: Eurocode 2: Design of concrete structures
  - The Netherlands: NEN 8700: Assessment of existing structures in case of reconstruction and disapproval - Basic Rules
  - The Netherlands: NEN 8701: Assessment of existing structures in case of reconstruction and disapproval – Actions
  - The Netherlands: Guideline for the assessment of structures
  - Switzerland: SIA 269-0: Existing structures - Bases
  - Switzerland: SIA 269-1: Existing structures - Actions
  - Switzerland: SIA 269-2: Existing structures - Concrete structures
  - Italy: Guidelines for the risk classification and management, safety assessment and monitoring of existing bridges
  - UK: CS 454 Assessment of highway bridges and structures
  - UK: CS 455 The assessment of concrete highway bridges and structures
  - UK: CS 456 The assessment of steel highway bridges and structures
  - UK: CS 459 The assessment of bridge substructures, retaining structures and buried structures

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Overview of current state of standardization

Data-informed safety assessment

Country / Standardisation body	Standard / guideline	Levels of assessment	Reliability levels	Types of structure-specific information	Parameters considered for updating	Consideration of deterioration
	prEN 1990-2 (2nd draft)	1) Preliminary assessment 2) Detailed assessment	May be lower than those used for the desing	• Available information from the original design and construction • Inspection outcomes • Test results	• Geometric data • Material properties • Permanent, imposed and variable actions	General principles
	prEN 1992-1-1	Not specified	Not specified	• Inspection outcomes • Material test results	• Geometric data • Material properties	No
	Guidelines for risk classification and management, safety assessment and monitoring of existing bridges	1) Preliminary structural assessment 2) Detailed structural assessment	Same levels used for design	• Available information from the original design and construction • Inspection outcomes • Test results	• Geometric data • Material properties • Permanent actions	General principles
	CS 455 The assessment of concrete highway bridges and structures CS 456 The assessment of steel highway bridges and structures-web	1) Simple structural analysis methods 2) Refined structural analysis methods, including non-linear or plastic analysis methods 3) Assessment based on material properties derived from testing samples of the structure, or use of bridge-specific assessment live loading models derived from the measurement of loading data	Same levels used for design, but reduced partial factors for materials if the “worst credible strength” is used in the calculations	• Available information from the original design and construction • Inspection outcomes • Test results	• Geometric data • Material properties	• Alkali-aggregate reaction • Delayed ettringite formation • Thaumasite • Corrosion of the reinforcement • Fatigue

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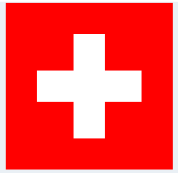
Overview of current state of standardization

Data-informed safety assessment

Country / Standardisation body	Standard / guideline	Levels of assessment	Reliability levels	Types of structure-specific information	Parameters considered for updating	Consideration of deterioration
	Reliability-based classification of the load carrying capacity of existing bridges	Not specified	Same levels used for design	• Available information from the original design and construction • Inspection outcomes • Test results	• Geometric data • Material properties • Actions • Events (load testing, cracking)	No detailed rules are given
	SIA 269 Bases for examination and intervention SIA 269/1 Existing structures – Actions SIA 269/2 Existing structures – Concrete structures SIA 269/3 Existing structures – Steel structures	1) Preliminary structural assessment 2) Detailed structural assessment	May be lower than those used for the desing	• Available information from the original design and construction • Inspection outcomes • Test results (incl. NDT)	• Geometric data • Material properties • Actions	• Alkali-aggregate reaction • Corrosion of the reinforcement • Fatigue

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