Joint Workshop of COST Actions TU0601 and E55
September 21-22 2009, Ljubljana, Slovenia

Categorisation and assessment of robustness related provisions in European standards

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Summary

A fundamental aim of modern codes of practice is to provide a suitable basis for the design of structures that ensures adequate structural safety with efficient and cost effective material use. The requirements necessary to fulfil this aim can be viewed to comprise of i) a standard safety format that incorporates models of material and structural behaviour and appropriate factors of safety, and ii) provisions to ensure adequate robustness. However, the provisions under these two categories are presently not separated in a clear and consistent manner in modern codes or standards. In order to enhance the general strategy for ensuring safety and robustness in structures, an effective understanding and systematic categorisation of the existing robustness related provisions in codes of practice is first necessary.

Towards this end, a review of European standards dealing with the design, execution, material aspects and maintenance of concrete and steel structures has been carried out. The robustness related provisions in these standards are identified and categorised using five fields related to different aspects of risk management in structures: approach to risk treatment, nature of risk control, relationship with event/exposure, manner of reducing risk and the phase of the life cycle of the structure at which the provision is applicable. This categorisation provides a systematic and differentiated picture of the treatment of robustness in European standards and also serves as a viable and rational platform for the future establishment of improved or optimal provisions for robustness in structures.

Keywords

Robustness, robustness provisions, structural safety.

Background

The provision of adequate safety in structures is set out in modern code based design and assessment procedures in the form of requirements that comprise:

- a standard safety format that incorporates models of material and structural behaviour and appropriate factors of safety, and

- provisions to ensure adequate robustness

The requirements covered under these two categories (as well as requirements for adequate quality control and supervision of the design and execution processes) are largely independent and need to be fulfilled individually (Beeby, 1999).

However a well defined separation does not presently exist between the standard safety format and the provisions for robustness. While operating within the domain of code based design as far as the standard safety format is concerned, a starting ground for establishing sound assessment procedures and achieving improvement of robustness of structures would be to clearly isolate the requirements under the two categories (Faber, 2009). This demands an effective understanding of the treatment of robustness in modern structural codes. For this purpose, it is first necessary to establish a systematic categorization of robustness related provisions, particularly covering the different aspects and interpretations concerning robustness. Towards this end, a review of European standards dealing with the design, execution, material aspects and maintenance of concrete and steel structures has been carried out in order to identify and categorize the robustness related provisions. The standards reviewed are listed in Appendix 1.

Methodology

Following the method of assessment of structural robustness proposed in Baker et al. (2008), a robust structure/ system can be considered to be one in which indirect risks do not contribute significantly to the total system risk, provided the prevailing direct risks are deemed to be acceptable. The fields used for categorization of the robustness related provisions are hence related to different aspects of risk management in structures and are listed below:

- Approach to risk treatment
- Nature of risk control
- Relationship with event/exposure
- Manner of reducing risk
- Phase of life cycle of structure at which the provision was applicable

Approach to risk treatment

The following four approaches are used for categorisation of the provisions on the basis of their engineering approach in dealing with robustness; these are adapted from Menzies (2006).

Structural measures – This approach is based on the implementation of measures to adequately resist the effects of an unaccounted / unforeseen / accidental event. These include the provision of:

- improved local resistance (strength and/or ductility) of selected critical components

- multiple independent load paths to ensure redundancy, and
- system failure reduction measures such as tying or segmentation.

Avoidance –The avoidance approach aims at the avoidance of extreme actions and their ensuing consequences through the adoption of measures such as:

- quality management to minimise the occurrence of errors and ensure efficient design, detailing and execution
- (preventive) replacement of components to ensure sufficient reliability throughout the intended design life
- release mechanisms for energy dissipation

Protection – The basis of the protection approach lies in the use of measures that modify a structure, its components or its ambient environment so that risks from events to which the structure is exposed to are reduced. These include, for instance, the placement of protective barriers to protect a structure from impact and the use of protective coatings and membranes against corrosion

Sacrifice – The sacrifice approach involves the sacrifice of the structure or a part of it in order to reduce consequences. Examples of this approach are the provision of sacrificial venting components to reduce the effect of explosions and the use of sacrificial anodes against corrosion.

These four approaches can be considered partly analogous to the risk reduction approaches – deny, detect, deter and devalue, used by the US Department of Homeland Security in connection with risk mitigation measures in building design (FEMA 452, 2005).

Nature of risk control

Provisions are grouped into 2 categories – active or passive, along the lines of the categorization used in structural fire protection. Active measures can be seen as “direct” measures that confront unforeseen/ accidental actions in order to minimise damage to the structure. On the other hand, passive measures aim at risk reduction through, for instance, preventive or protective means.

Relationship with event/exposure

Here the classification of robustness related provisions is carried out on the basis of whether they are event/exposure specific (e.g.: cathodic protection against corrosion) or independent (e.g.: provision of structural ties).

Manner of reducing risk

When considered over the entire range of exposures possible for the structure under consideration, the quantities contributing to indirect risks for a structure/system are (BS EN 1991-1-7, 2006):

- probability of occurrence of an exposure / event having the potential to cause local damage or system failure in the system

- probability of occurrence of local damage given the occurrence of an exposure
- probability of occurrence of system failure given the occurrence of local damage
- consequences arising from system failure and loss of system functionality

Accordingly, the provisions are classified into one of the above four categories with respect to their manner of reducing risk.

Applicability in life cycle of structure

The provisions are grouped into one of the following three categories, depending on the phase of the life cycle of the structure in which they are relevant and applicable:

- planning and design
- execution
- operation and maintenance

Discussion

Appendix 2 provides a listing of all identified robustness related provisions in the standards together with their categorization.

As far as approach to risk treatment is concerned, it is seen that several provisions particularly those dealing with unforeseen actions fall under the "structural measures" approach, with the provision of increased local resistance for selected components, tying systems, ductility and redundancy being the most commonly found measures. In contrast, the use of segmentation as a strategy for risk control is not recommended, except in the context of fire design where compartmentation is linked to the performance criteria of integrity. Even though detailed methods and prescriptive rules are provided for several provisions, there is no explicit link/ relationship between the implementation of these measures and the achieved level of robustness.

Provisions falling under the avoidance, protection and sacrifice approaches to risk treatment are seen to be either i) of a general guidance nature (e.g. avoidance of errors through quality management) or ii) those that deal with event specific or identified accidental actions (e.g. protection against, corrosion risks through cathodic protection, provision of adequate clearances to guard against impact)

A majority of the measures require to be implemented during the planning, design and execution phases of a structure. It is implicitly assumed that provided these measures are adequately and efficiently implemented, a sufficient (though not specified) level of robustness remains during the life of the structure. There are no provisions for some form of "robustness monitoring" during the operational life of the structure. This also has implications for robustness assessment and improvement of existing structures.

With regard to the manner of reducing risk, the effect of measures such as limits for localised failure, incorporation of redundancy and provision of tying systems that aim to minimise the occurrence of system failure is implicit and not elaborated or spelt out explicitly. This can also be said of measures such as the provision of ductility and avoidance of brittle failure that help to contain consequences.

Outlook

The proposed categorisation provides a systematic and differentiated mapping of the treatment of robustness in European standards. This would enable the identification of possible areas where i) redundant provisions concerning robustness exist and ii) the code provisions are presently inadequate. Also a viable and rational platform for the establishment of improved or optimal provisions for robustness in structures is made available through this categorization. Assuming that the standard safety format is already optimized, the optimization of the identified robustness provisions can be separately carried out on the basis of overall cost efficiency and the Life Quality Index (Nathwani et al., 1997) criterion concerning marginal life safety investments.

References

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Appendix 1 – List of reviewed standards

BS EN 1990:2002/A1:2005/AC:2008. Eurocode - Basis of structural design. British Standards Institution, London.

BS EN 1991-1-2:2002/AC:2009. Eurocode 1: Actions on structures - Part 1-2: General actions - Actions on structures exposed to fire. British Standards Institution, London.

BS EN 1991-1-7:2006. Eurocode 1 – Actions on Structures – Part 1-7: General Actions – Accidental Actions, British Standards Institution, London.

BS EN 1991-2:2003. Eurocode 1: Actions on structures - Part 2: Traffic loads on bridges. British Standards Institution, London.

BS EN 1992-1-1:2004/AC:2008. Eurocode 2: Design of concrete structures - Part 1-1: General rules and rules for buildings. British Standards Institution, London.

BS EN 1992-1-2:2004/AC:2008. Eurocode 2: Design of concrete structures - Part 1-2: General rules - Structural fire design. British Standards Institution, London.

BS EN 1992-2:2005/AC:2008. Eurocode 2 - Design of concrete structures - Concrete bridges - Design and detailing rules. British Standards Institution, London.

BS EN 206-1:2000/A2:2005. Concrete - Part 1: Specification performance, production and conformity. British Standards Institution, London.

DD ENV 13670-1:2000. Execution of concrete structures - Part 1: Common. British Standards Institution, London.

BS EN 1504-9:2008. Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 9: General principles for the use of products and systems. British Standards Institution, London.

BS EN 1993-1-1:2005/AC:2009. Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings. British Standards Institution, London.

BS EN 1993-1-2:2005/AC:2009. Eurocode 3: Design of steel structures - Part 1-2: General rules - Structural fire design. British Standards Institution, London.

BS EN 1993-1-8:2005/AC:2009. Eurocode 3: Design of steel structures - Part 1-8: Design of joints. British Standards Institution, London.

BS EN 1993-2:2006. Eurocode 3 - Design of steel structures - Part 2: Steel Bridges. British Standards Institution, London.

BS EN 1090-1:2009. Execution of steel structures and aluminium structures - Part 1: Requirements for conformity assessment of structural components. British Standards Institution, London.

BS EN 1090-2:2008. Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures. British Standards Institution, London.

BS EN 10025-1:2004. Hot rolled products of structural steels - Part 1: General technical delivery conditions. British Standards Institution, London.

Appendix 2 – Categorization of robustness related provisions

CLAUSE	TEXT	CATEGORIZATION				
		APPROACH TO RISK TREATMENT	**NATURE OF RISK CONTROL**	**RELATION WITH EVENT / EXPOSURE**	**MANNER OF RISK REDUCTION**	**APPLICABILITY IN LIFE CYCLE OF STRUCTURE**
EN 1990 : 2002						
2.1 (4) P	A structure shall be designed and executed in such a way that it will not be damaged by events such as : – explosion, – impact, and – the consequences of human errors, to an extent disproportionate to the original cause.					
2.1 (5) P	Potential damage shall be avoided or limited by appropriate choice of one or more of the following : 1– avoiding, eliminating or reducing the hazards to which the structure can be subjected; 2– selecting a structural form which has low sensitivity to the hazards considered ; 3– selecting a structural form and design that can survive adequately the accidental removal of an individual member or a limited part of the structure, or the occurrence of acceptable localised damage ; 4– avoiding as far as possible structural systems that can collapse without warning ; 5– tying the structural members together.	1 – avoidance 1 – protection 2,3,4,5 – structural measures	1, 4 – passive 2,3,5 – active	1,2,3,4,5 – independent 1 - specific	1 – exposure 2,3 – local damage 3,5 – system failure 4 – consequences	1,2,3,4 – planning and design 1,5 – design and execution
2.2 (2) and (3)	Different levels of reliability may be adopted inter alia : – for structural resistance ; – for serviceability. The choice of the levels of reliability for a particular structure should take account of the relevant factors, including : 1– the possible cause and /or mode of attaining a limit	1,2,3,4 – structural measures				

CLAUSE	TEXT	CATEGORIZATION				
		APPROACH TO RISK TREATMENT	**NATURE OF RISK CONTROL**	**RELATION WITH EVENT / EXPOSURE**	**MANNER OF RISK REDUCTION**	**APPLICABILITY IN LIFE CYCLE OF STRUCTURE**
	state ; 2– the possible consequences of failure in terms of risk to life, injury, potential economical losses ; 3– public aversion to failure ; 4– the expense and procedures necessary to reduce the risk of failure.					
2.2 (5)	The levels of reliability relating to structural resistance and serviceability can be achieved by suitable combinations of : a) preventative and protective measures (e.g. implementation of safety barriers, active and passive protective measures against fire, protection against risks of corrosion such as painting or cathodic protection) ; b) measures relating to design calculations : – representative values of actions ; – the choice of partial factors ; c) measures relating to quality management ; d) measures aimed to reduce errors in design and execution of the structure, and gross human errors ; e) other measures relating to the following other design matters : – the basic requirements ; – the degree of robustness (structural integrity) ; – durability, including the choice of the design working life ; – the extent and quality of preliminary investigations of soils and possible environmental influences ; – the accuracy of the mechanical models used ; – the detailing ; f) efficient execution, e.g. in accordance with execution standards referred to in EN 1991 to EN 1999. g) adequate inspection and maintenance according to	a – protection b – structural measures c,d,f,g – avoidance	a,b – passive a,c,d,e,f,g – active	b,c,d,e,f,g – independent a - specific	a – exposure b,e,f,g – local damage e,f,g – system failure c,d – all	a,b,c,d,e – planning and design a,c,d,f – execution g – operation and maintenance

CLAUSE	TEXT	CATEGORIZATION				
		APPROACH TO RISK TREATMENT	**NATURE OF RISK CONTROL**	**RELATION WITH EVENT / EXPOSURE**	**MANNER OF RISK REDUCTION**	**APPLICABILITY IN LIFE CYCLE OF STRUCTURE**
	procedures specified in the project documentation.					
2.4 (1) and (2)	The structure shall be designed such that deterioration over its design working life does not impair the performance of the structure below that intended, having due regard to its environment and the anticipated level of maintenance. In order to achieve an adequately durable structure, the following should be taken into account : – the intended or foreseeable use of the structure ; – the required design criteria ; – the expected environmental conditions ; – the composition, properties and performance of the materials and products ; – the properties of the soil ; – the choice of the structural system ; – the shape of members and the structural detailing ; – the quality of workmanship, and the level of control ; – the particular protective measures ; – the intended maintenance during the design working life.	structural measures avoidance protection	active passive	independent specific	local damage consequences	planning and design execution operation and maintenance
EN 1991-1-7 : 2006						
3.2 (2)	A localised failure due to accidental actions may be acceptable, provided it will not endanger the stability of the whole structure and that the overall load-bearing capacity of the structure is maintained and allows necessary emergency measures to be taken. NOTE 1 For building structures such emergency measures may involve the safe evacuation of persons from the premises and its surroundings. NOTE 2 For bridge structures such emergency measures may involve the closure of the road or rail	avoidance sacrifice	passive	independent	system failure consequences	planning and design execution operation and maintenance

CLAUSE	TEXT	CATEGORIZATION				
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	service within a specific limited period.					
3.2 (3)	Measures should be taken to mitigate the risk of accidental actions and these measures should include, as appropriate, one or more of the following strategies: a) preventing the action from occurring (e.g. in the case of bridges, by providing adequate clearances between the trafficked lanes and the structure) or reducing the probability and/or magnitude of the action to an acceptable level through the structural design process (e.g. in the case of buildings providing sacrificial venting components with a low mass and strength to reduce the effect of explosions); b) protecting the structure against the effects of an accidental action by reducing the effects of the action on the structure (e.g. by protective bollards or safety barriers); c) ensuring that the structure has sufficient robustness by adopting one or more of the following approaches: 1) by designing certain components of the structure upon which stability depends as key elements (see 1.5.10) to increase the likelihood of the structure's survival following an accidental event. 2) designing structural members, and selecting materials, to have sufficient ductility capable of absorbing significant strain energy without rupture. 3) incorporating sufficient redundancy in the structure to facilitate the transfer of actions to alternative load paths following an accidental event.	a – avoidance a – sacrifice b – protection c1,c2,c3 – structural measures	a,b,c2 – passive c1,c3 – active	c1,c2,c3 – independent a,b - specific	a – exposure a,b,c1,c2,c3 – local damage c1,c2,c3 – system failure c2 – consequences	a,b,c1,c2,c3 – planning and design a,b – execution
3.3 (2)	The mitigation should be reached by adopting one or more of the following approaches:	a,c – structural	b,c – passive	a,b,c – independent	a – local damage	a,b,c – planning and design

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	a) designing key elements, on which the stability of the structure depends, to sustain the effects of a model of accidental action A_d; NOTE 1 The National Annex may define the model which may be a concentrated or a distributed load with a design value of A_d. The recommended model for buildings is a uniformly distributed notional load applicable in any direction to the key element and any attached components (e.g. claddings, etc). The recommended value for the uniformly distributed load is 34 kN/m^2 for building structures. An example of the application of A_d is given in A.8. b) designing the structure so that in the event of a localised failure (e.g. failure of a single member) the stability of the whole structure or of a significant part of it would not be endangered; NOTE 2 The National Annex may state the acceptable limit of "localised failure". The indicative limit for building structures is 100 m^2 or 15 % of the floor area, whichever is less, on two adjacent floors caused by the removal of any supporting column, pier or wall. This is likely to provide the structure with sufficient robustness regardless of whether an identified accidental action has been taken into account. c) applying prescriptive design/detailing rules that provide acceptable robustness for the structure (e.g. three-dimensional tying for additional integrity, or a minimum level of ductility of structural members subject to impact).	measures b – avoidance	a,c – active		b,c – system failure c – consequences	
A.4 A.5 A.6	(1) Adoption of the following recommended strategies should provide a building with an acceptable level of robustness to sustain localised failure without a disproportionate level of collapse.	b,c – structural measures	b,c – active	b,c – independent	b,c – system failure	b,c – planning and design b,c – execution

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A.7 A.8	a) For buildings in Consequences Class 1: Provided a building has been designed and constructed in accordance with the rules given in EN 1990 to EN 1999 for satisfying stability in normal use, no further specific consideration is necessary with regard to accidental actions from unidentified causes. b) For buildings in Consequences Class 2a (Lower Group): In addition to the recommended strategies for Consequences Class 1, the provision of effective horizontal ties, or effective anchorage of suspended floors to walls, as defined in A.5.1 and A.5.2 respectively for framed and load-bearing wall construction should be provided. NOTE 1 Details of effective anchorage may be given in the National Annex. c) For buildings in Consequences Class 2b (Upper Group): In addition to the recommended strategies for Consequences Class 1, the provision of: – horizontal ties, as defined in A.5.1 and A.5.2 respectively for framed and load-bearing wall construction (see 1.5.11), together with vertical ties, as defined in A.6, in all supporting columns and walls should be provided, or alternatively, – the building should be checked to ensure that upon the notional removal of each supporting column and each beam supporting a column, or any nominal section of load-bearing wall as defined in A.7 (one at a time in each storey of the building) the building remains stable and that any local damage does not exceed a certain limit.					

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	Where the notional removal of such columns and sections of walls would result in an extent of damage in excess of the agreed limit, or other such limit specified, then such elements should be designed as a "key element" (see A.8). In the case of buildings of load-bearing wall construction, the notional removal of a section of wall, one at a time, is likely to be the most practical strategy to adopt. For buildings in Consequences Class 3: A systematic risk assessment of the building should be undertaken taking into account both foreseeable and unforeseeable hazards.					
EN 1992-1-1 : 2004						
3.2.4 (1)P	The reinforcement shall have adequate ductility as defined by the ratio of tensile strength to the yield stress, $(f_t/f_y)_k$ and the elongation at maximum force, ε_{uk}.	structural measures	passive	independent	consequences	planning and design execution
4.1	(1)P A durable structure shall meet the requirements of serviceability, strength and stability throughout its design working life, without significant loss of utility or excessive unforeseen maintenance (for general requirements see also EN 1990). (2)P The required protection of the structure shall be established by considering its intended use, design working life (see EN 1990), maintenance programme and actions. (3)P The possible significance of direct and indirect actions, environmental conditions (4.2) and consequential effects shall be considered. Note: Examples include deformations due to creep and	structural measures protection	active passive	specific	local damage consequences	planning and design execution operation and maintenance

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         4.3 E.1	shrinkage (see 2.3.2). (4) Corrosion protection of steel reinforcement depends on density, quality and thickness of concrete cover (see 4.4) and cracking (see 7.3). The cover density and quality is achieved by controlling the maximum water/cement ratio and minimum cement content (see EN 206-1) and may be related to a minimum strength class of concrete. (1)P In order to achieve the required design working life of the structure, adequate measures shall be taken to protect each structural element against the relevant environmental actions. (1) The choice of adequately durable concrete for corrosion protection of reinforcement and protection of concrete attack, requires consideration of the composition of concrete. This may result in a higher compressive strength of the concrete than is required for structural design. The relationship between concrete strength classes and exposure classes (see Table 4.1) may be described by indicative strength classes.					
9.1 (3)	Minimum areas of reinforcement are given in order to prevent a brittle failure, wide cracks and also to resist forces arising from restrained actions.	avoidance	passive	independent	local damage consequences	planning and design execution
9.10.1	(1)P Structures which are not designed to withstand accidental actions shall have a suitable tying system, to prevent progressive collapse by providing alternative load paths after local damage. The following simple rules are deemed to satisfy this	structural measures	active	independent	system failure	planning and design execution

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	requirement. (2) The following ties should be provided: a) peripheral ties b) internal ties c) horizontal column or wall ties d) where required, vertical ties, particularly in panel buildings.					
EN 1993-1-1 : 2005						
3.2.2	Ductility requirements (1) For steels a minimum ductility is required that should be expressed in terms of limits for: – the ratio f_u / f_y of the specified minimum ultimate tensile strength f_u to the specified minimum yield strength f_y; – the elongation at failure on a gauge length of 5,65 $\sqrt{A_0}$ (where A_0 is the original cross-sectional area); – the ultimate strain ε_u, where ε_u corresponds to the ultimate strength f_u . NOTE The limiting values of the ratio f_u / f_y , the elongation at failure and the ultimate strain ε_u may be defined in the National Annex. The following values are recommended: – $f_u / f_y \geq 1,10$; – elongation at failure not less than 15%; – $\varepsilon_u \geq 15\varepsilon_y$, where ε_y is the yield strain ($\varepsilon_y = f_y / E$). (2) Steel conforming with one of the steel grades listed in Table 3.1 should be accepted as satisfying these requirements.	structural measures	passive	independent	consequences	planning and design execution
4	(2) The means of executing the protective treatment undertaken off-site and on-site shall be in accordance with EN 1090.	avoidance protection	passive	specific	local damage consequences	planning and design

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	(3) Parts susceptible to corrosion, mechanical wear or fatigue should be designed such that inspection, maintenance and reconstruction can be carried out satisfactorily and access is available for in-service inspection and maintenance. (5) For elements that cannot be inspected an appropriate corrosion allowance shall be included.					execution operation and maintenance
EN 1991-2 : 2003						
5.6.2	(1) The measures to protect a footbridge should be defined. NOTE Footbridges (piers and decks) are generally much more sensitive to collision forces than road bridges. Designing them for the same collision load may be unrealistic. The most effective way to take collision into account generally consists of protecting the footbridges : – by road restraint systems at appropriate distances before piers, – by a higher clearance than for neighbouring road or railway bridges over the same road in the absence of intermediate access to the road.	avoidance protection	passive	specific	exposure local damage	planning and design execution
EN 1993-2 : 2006						
2.1.3.4	(1) The design of the bridge should ensure that when the damage of a component due to accidental actions occurs, the remaining structure can sustain at least the accidental load combination with reasonable means. NOTE: The National Annex may define components that are subject to accidental design situations and also details for assessments. Examples of such components are hangers, cables, bearings. (2) The effects of corrosion or fatigue of components	structural measures	active	independent	local damage	planning and design execution

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	and material should be taken into account by appropriate detailing, see also EN 1993-1-9 and EN 1993-1-10.					
2.1.3.4	(4) For elements that cannot be inspected fatigue checks should be carried out (see EN 1993-1-9) and appropriate corrosion allowances should be provided. (6) Components that cannot be designed with sufficient reliability to achieve the total design working life of the bridge should be replaceable. These may include: – stays, cables, hangers; – bearings; – expansion joints; – drainage devices; – guardrails, parapets; – asphalt layer and other surface protection; – wind shields; – noise barriers.	avoidance	passive	independent	local damage	planning and design execution
EN 1992-1-2 : 2004						
2.1.1	(2)P Where compartmentation is required, the elements forming the boundaries of the fire compartment, including joints, shall be designed and constructed in such a way that they maintain their separating function during the relevant fire exposure. This shall ensure, where relevant, that: - integrity failure does not occur, see EN 1991-1-2 - insulation failure does not occur, see EN 1991-1 -2 - thermal radiation from the unexposed side is limited. (1)P For the standard fire exposure, members shall comply with criteria R, E and I as follows:	structural measures	passive	specific	system failure consequences	planning and design execution

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2.1.2	- separating only: integrity (criterion E) and, when requested, insulation (criterion I) - load bearing only: mechanical resistance (criterion R) - separating and load bearing: criteria R, E and, when requested I					
5.2	(1) Requirements for separating function (Criterion E and I (see 2.1.2)) may be considered satisfied where the minimum thickness of walls or slabs is in accordance with Table 5.3. For joints reference should be made to 4.6.	structural measures sacrifice	passive	specific	system failure consequences	planning and design execution