

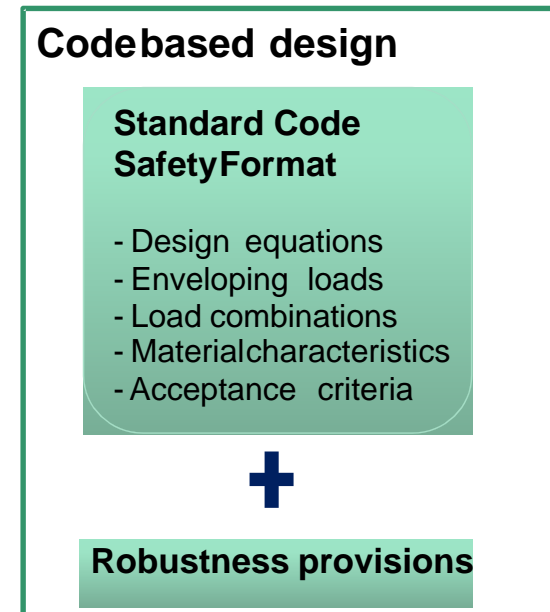
COST Action TU0601
Robustness of Structures
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Categorisation and assessment of robustness related provisions in European standards

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- Provision of adequate safety in structures is set out in modern codes in the form of requirements comprising:

- **a standard safety format**
- **provisions to ensure adequate robustness.**



- These requirements are largely independent and need to be fulfilled individually.

- A **well defined separation** does not presently exist between the standard safety format and the provisions for robustness.
- A **preliminary basis** for establishing sound assessment and achieving improvement of robustness would be to **clearly isolate** the requirements under the two categories.
- This demands an effective understanding of the treatment of robustness in modern structural codes.

- A review of European standards for design, execution, material aspects and maintenance of concrete and steel structures carried out.
- Robustness related provisions identified and a systematic categorization established.
- Fields of categorization related to different aspects of risk management in structures.

Fields of categorization

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

Approach to risk treatment

- **Structural measures / resist unforeseen actions**
Implementation of measures to adequately resist the effects of an unforeseen/ accidental event
- **Avoidance**
Avoidance of extreme actions and ensuing consequences
- **Protection**
Modification of structure, components or ambient environment to reduce risks
- **Sacrifice**
Sacrifice of the structure or a part to reduce consequences

Nature of risk control

- Active

“Direct” measures that confront unforeseen/ accidental actions

- Passive

Risk reduction through preventive or protective means

Relationship with event/exposure

- Specific
- Independent

Manner of reducing risk

- Probability of occurrence of an exposure / event
- Probability of occurrence of local damage
- Probability of occurrence of system failure
- Consequences arising from system failure and loss of system functionality

Phase of life cycle of structure in which the provision is applicable

- Planning and design
- Execution
- Operation and maintenance

Listing and categorization of identified
robustness related provisions in European
standards

Approach to risk treatment

- Several provisions particularly those dealing with unforeseen actions fall under “Structural measures / resist unforeseen actions” category
- Commonly found measures include increased local resistance for selected components, tying systems, ductility and redundancy.
- Use of segmentation as a strategy for risk control is not recommended, except in the context of fire design.

Approach to risk treatment

- No explicit link/ relationship between the implementation of these measures and the achieved level of robustness.
- Provisions under avoidance, protection and sacrifice approaches to risk treatment are:
 - of a general guidance nature, or
 - dealing with event specific or identified accidental actions

Robustness provisions during the life cycle of a structure

- Majority of measures require to be implemented during the planning, design and execution phases.
- 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.

Robustness provisions during the life cycle of a 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.

Manner of risk reduction

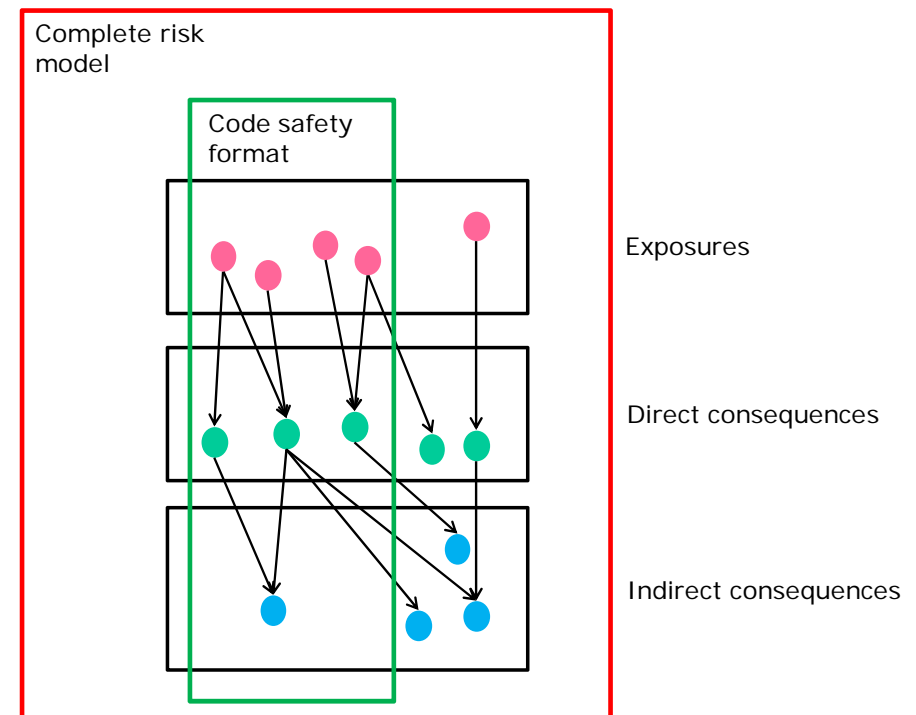
- Effect of measures such as limits for localised failure, incorporation of redundancy and provision of tying systems that aim to minimise the occurrence of system failure is implied and not elaborated or spelt out explicitly.
- This is also true of measures such as provision of ductility and avoidance of brittle failure that help to contain consequences.

Outlook – optimal provisions for robustness

Ideal approach

Joint optimization of :

- standard safety format
- robustness provisions



Outlook – optimal provisions for robustness

Practical approach

- Standard safety format is considered already optimized.
- Robustness provisions can be optimized considering:
 - life safety
 - overall cost efficiency

