Improving fire safety through engineering (rational designs)

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Fire Safety Indaba, Cape Town 2013

Introduction

- What is fire safety engineering?
- What is a rational design?
- What is the enabling legislation?
- What is the process?

Fire safety engineering

- According to the UK IFE definition:

Fire Engineering is the application of scientific and engineering principles, rules [Codes], and expert judgement, based on an understanding of the phenomena and effects of fire and of the reaction and behaviour of people to fire, to protect people, property and the environment from the destructive effects of fire.

What is a rational design?

- According to SANS 10400-T: 2011

Undertaken by a competent person to achieve the same level of fire safety implied in 4.2 to 4.59

- According to an article which appeared in the "Engineering News":

Rational fire design is the detailed design of fire safety and prevention mechanisms and strategies in a building in order to comply with the National Building Regulations, where prescriptive requirements cannot be met.

Applicable legislation

Applicable legislation

- The Fire Brigade Services Act As amended
- The function of SANS codes and standards
- Local Authority By-Laws
- National Veld and Forest Fire Act (Act 101 of 1998)
- National Building Regulations and Building Standards Act (Act 103 of 1977 as amended)
- National Building Regulations (Parts A, T and W)
- Occupational Health and Safety Act and Regulations

What is the enabling legislation?

National Building Regulations and Building Standards Act, (Act 103 of 1977 as amended):

SANS 10400-T:2011:

- Annex A: T1(2)
- 4.1.1 (b)
- Note 1,2 and 3

Most importantly: Annex B: B.1 and B.2:

Shall be undertaken by competent person in accordance with the requirements of BS 7974

(design requirements and framework application)

The function of BS 7974 in South Africa

Annex B of SANS 10400 indicates that:

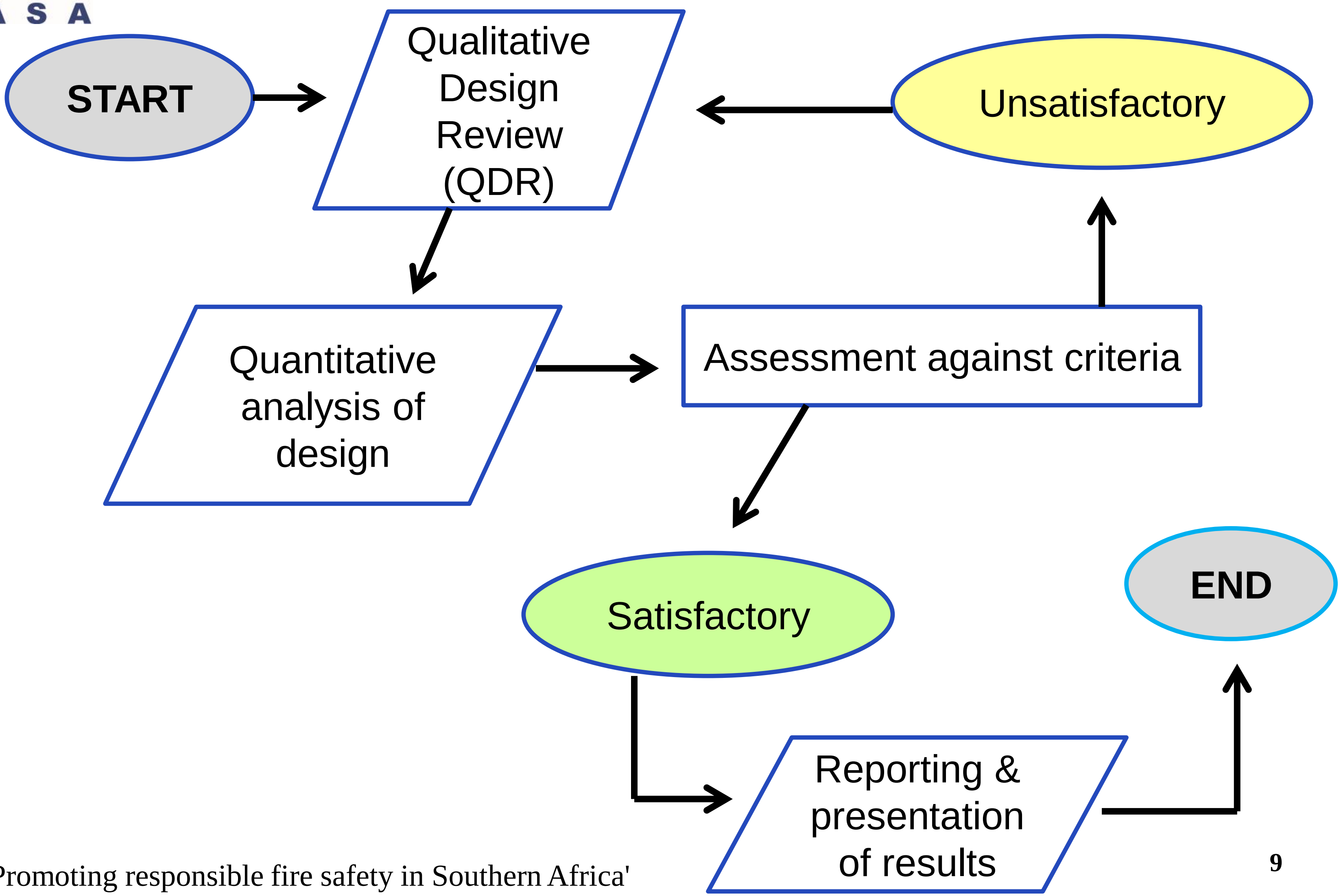
- Rational designs should achieve the same level of safety implied in Part T
- Rational designs shall be in accordance with BS 7974
- Any relevant standards or technical documents can be used during the process

The function of BS 7974 in South Africa

BS 7974 provides a process by which:

- Competent persons can demonstrate that due diligence has been applied during the design process
- Approving authorities can assess that due diligence has been applied

The fire engineering process



The Design Process

At its most superficial level, it is recommended that a fire engineered project should comprise of the following three stages:

1. **Qualitative design review (QDR)**
2. **Quantitative analysis**
3. **Assessment against criteria**

QDR Flowchart

Document QDR process so that the underlying philosophies and assumptions can be understood by third parties

QDR: Review of architectural design

- Building characterisation:
  Layout, geometry, construction
- Environmental influences:
  Climatic conditions affecting structural load, smoke ventilation, external fire spread
- Occupant characteristics:
  occupancy type, population, distribution, AFD
- Management of fire safety:
  Likely extent and nature of building management

QDR Flowchart

Document QDR process so that the underlying philosophies and assumptions can be understood by third parties

QDR: Establish fire safety objectives

Life safety

- Occupants can leave relatively safely or risk to occupants is low
- Fire-fighters can operate in reasonable safety
- Collapse does not endanger people near the building

QDR: Establish fire safety objectives

Loss prevention

Minimise fire damage to:

- Structure and fabric of the building
- Building contents
- On-going business viability
- Corporate image

QDR: Establish fire safety objectives

Environmental protection

Limit:

- Effects on adjacent buildings or facilities
- Release of hazardous materials into environment

QDR Flowchart

Document QDR process so that the underlying philosophies and assumptions can be understood by third parties

QDR: Identification of fire hazards and consequences

Review to include:

- Ignition sources
- Combustible contents
- Construction materials
- Nature and activities of building
- Building layout
- Any unusual factors

Consider consequences on fire safety objectives under consideration

QDR Flowchart

Document QDR process so that the underlying philosophies and assumptions can be understood by third parties

QDR: Establish trial fire safety design

- Establish various fire protection strategies
- Select cost-effective strategies that satisfy criteria and meet objectives
- Actually establishing trial fire safety strategies
- Considerations when developing trial designs include:
  - Control on materials
  - Automatic suppression and detection
  - Compartmentation

QDR: Establish trial fire safety design

- Other automatic systems
- Smoke control
- Means of escape
- First aid fire-fighting
- Fire service facilities
- Fire safety management

QDR: Assessment criteria and converting objectives into engineering terms

Example for single storey warehouse – Life safety objective

OBJECTIVE	DESIGN TARGET	PERFORMANCE CRITERIA
OCCUPANTS ABLE TO LEAVE IN REASONABLE SAFETY	MAINTAIN TENABLE CONDITIONS ON ESCAPE ROUTES UNTIL OCCUPANTS HAVE EVACUATED	ENSURE SMOKE LAYER REMAINS: ✓ >2,5M ABOVE FLOOR ✓ < 200^0C UNTIL EVACUATION IS COMPLETE

QDR Flowchart

Document QDR process so that the underlying philosophies and assumptions can be understood by third parties

QDR: Acceptance criteria and methods of analysis

- Objectives are broad and not specific enough for a basis for engineering design
- Assessment criteria therefore needs to be set to ensure objectives have been met
- Objectives may need to be converted into engineering terms
- The most appropriate method of analysis also needs to be identified

QDR Flowchart

Document QDR process so that the underlying philosophies and assumptions can be understood by third parties

QDR: Establish fire scenarios for analysis (worst likely case)

Characterisation of fire scenarios for analysis should include the following where relevant:

- Fire type
- Internal/external ventilation conditions
- Performance of each fire safety measure
- Type, size and location of ignition sources
- Distribution and type of fuel

QDR: Establish fire scenarios for analysis (worst likely case)

- Fire load density
- Fire suppression
- State of doors
- Breakage of windows
- Building ventilation system

QDR: Establish fire scenarios for analysis

Consider the consequences for each fire scenario

Several fires may need to be modelled e.g.:

- A quick developing fire – may be worst for escape but easiest to detect
- A hot fire – may be worst in terms of smoke temperature but best in terms of smoke volume production
- A fire in the centre of a room may make escape difficult but in a corner will grow quickly

QDR: Establish fire scenarios for analysis

Characterise design fires in terms of:

- Heat release rate
- Toxic species production rate
- Smoke production rate
- Fire size
- Time to key events such as flashover

QDR: Establish fire scenarios for analysis

More complete descriptions of design fires may include:

- Incipient phase
- Growth phase
- Fully developed phase
- Decay phase
- Extinction

QDR: Establish fire scenarios for analysis

- To simplify smoke control calculations, it may be possible to assume a fully developed fire with a constant heat output from the time of ignition
- The location of the design fire should be specified (geometry of space and location in room)
- Location may influence fire service deployment time (e.g. upper floors of high rise versus single storey)

QDR: Establish fire scenarios for analysis (worst likely case)

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BS 7974:2001 - Application of fire safety engineering principles to the design of buildings – Code of Practice (Sub-systems)

PD-0:2002: Guide to the design framework and fire safety engineering procedures.

PD-1:2003: (Sub-system 1) initiation and development of fire within the enclosure of origin.

PD-2:2002: (Sub-system 2) spread of smoke and toxic gases within and beyond the enclosure of origin.

PD-3:2003: (Sub-system 3) structural response and fire spread beyond the enclosure of origin.

PD-4:2003: (Sub-system 4) detection of fire and activation of fire protection systems.

BS 7974:2001 - Application of fire safety engineering principles to the design of buildings – Code of Practice (Sub-systems continue)

PD-5:2002: (Sub-system 5) fire service intervention

PD-6:2004: (Sub-system 6) evacuation.

PD-7:2003: Probabilistic fire risk assessment

PD-8:2012: Property protection, business and mission continuity, and resilience

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Understanding the Quantitative Assessment component

Quantitative Analysis

- Having concluded the design criteria, objectives and acceptance criteria

  ……..

  someone now needs to prove and conclude the design
- A means of analysis and technical assessment must now be performed
- This may simply be logical reasoning

Quantitative Analysis

- Quantitative analysis is technical fire engineering
- Of the QDR team, only the fire engineer needs to be able to carry out the quantitative analysis.
- However, all concerned to have a working knowledge of the quantitative fire engineering process.

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Assessment against criteria

- Suitability of the fire safety design needs to be assessed against the objectives and design criteria identified during the QDR

In closing:

- Responsibility rests on Building Owner, appointed Fire Engineer, Building Control officer and the Fire Safety Officer to conclude that the rational design has satisfied the Regulations of SANS 10400-T:2011, T1 (1) (a) to (e) and (2)

Thank you.