

ITA - AITES WORLD TUNNEL CONGRESS 2007 PRAGUE



The 3rd Training course
TUNNELLING IN URBAN AREA
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Health and Safety in Tunnel Construction

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ASSOCIATION
INTERNATIONALE DES TRAVAUX
EN SOUTERRAIN
AITES



ITA
INTERNATIONAL
TUNNELLING
ASSOCIATION



1

Introduction

2

Chapter 1 – Occupational health

3

Chapter 2 - Welfare

4

Chapter 3 - Safety

5

Conclusions and references



1

Sources of guidance

2

- CEN Standards

- ITA publications

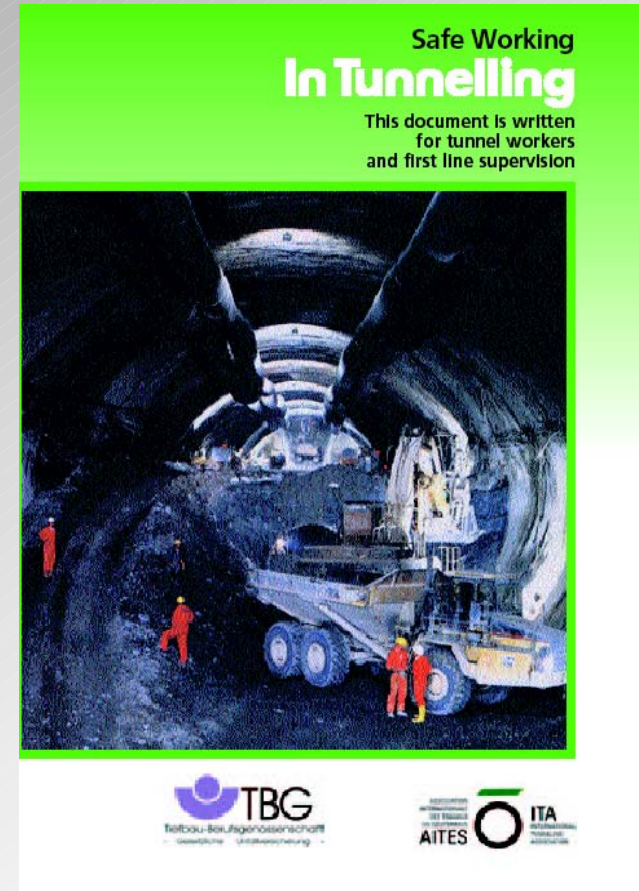
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- National legislation and standards

4

- Industry guidance

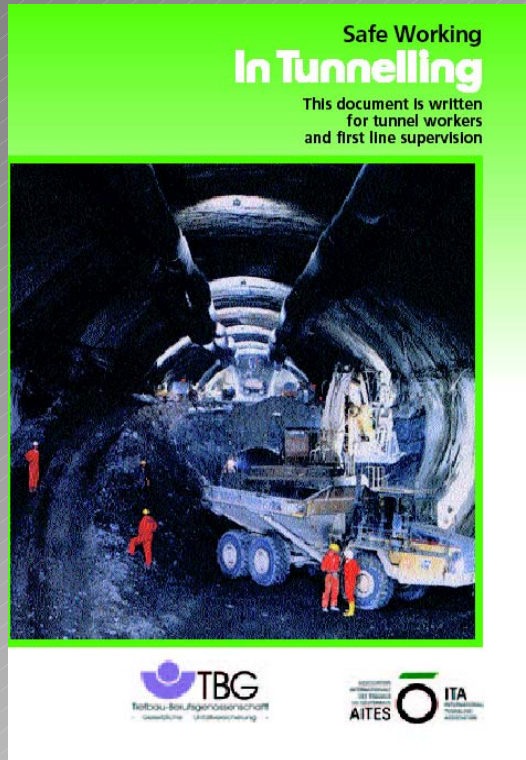
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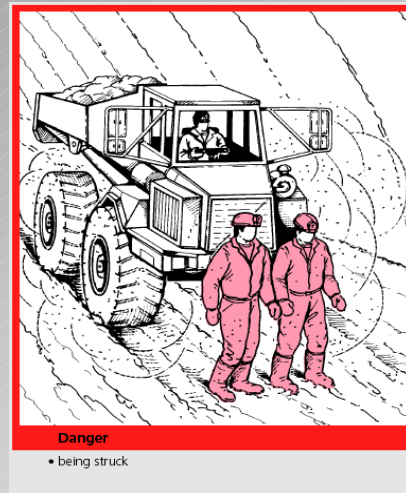
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ITA publication “Safe Working in Tunnelling”

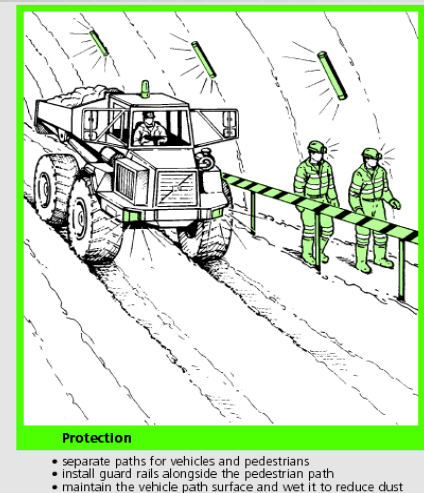
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The hazards of tunnelling are exacerbated by

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- Uncertainty and variability of ground

3

- Confined space of tunnel environment

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- Inadequate safety culture

5

- Lack of commitment by all parties

- Failure to learn from mistakes

- Work in compressed air

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Occupational health



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Occupational health

- To ensure fitness for work
 - e.g. Eye sight requirements for plant operators
- To address ill health due to work
 - e.g. Hand arm vibration syndrome from use of vibrating pneumatic tools

3

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Ill health in tunnelling

- General occupational ill health
 - No published data in UK
 - Very little published data worldwide
- Decompression illness
 - UK data published
 - Some data published for other countries also

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Occupational health hazards

2

- Cementitious materials – dermatitis

3

- Epoxy materials – dermatitis and respiratory problems

4

- Noise – hearing loss

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Occupational health hazards

3

- Heat strain
- Vibration
- Manual handling

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Occupational health hazards

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- Dust
- Soil

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conditioners

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Occupational health hazards

2

- Work in compressed air

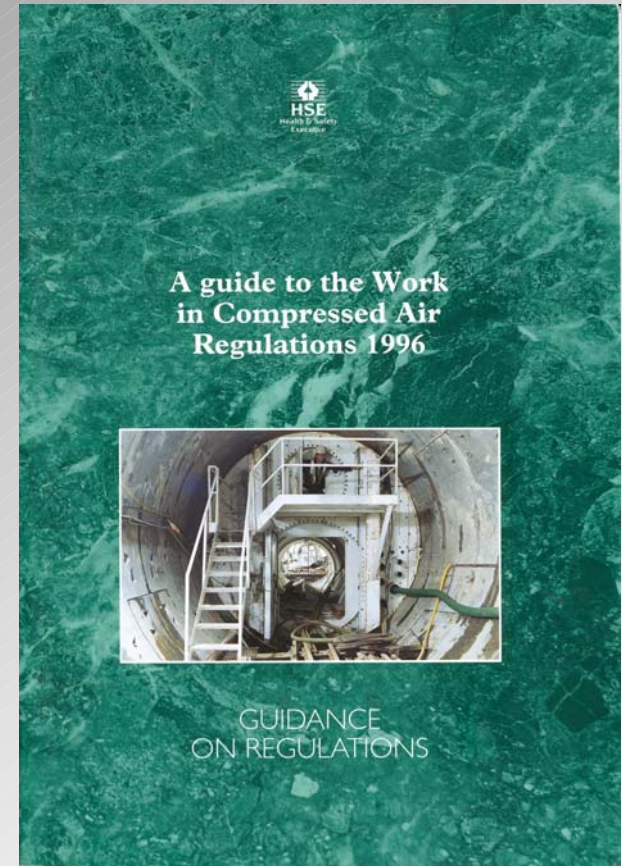
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- Decompression illness is a hazard

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- Risk of DCI reduced by use of oxygen

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Welfare



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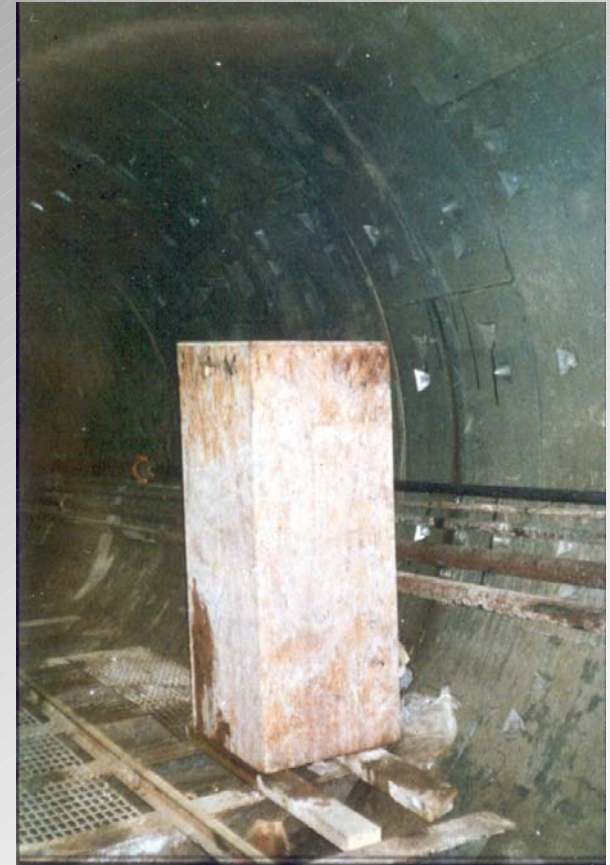
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- Welfare
 - Basic toilet facilities
 - Washing facilities
 - Drinking water
 - Messing facilities
 - First aid

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Safety

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Role of Client

- Sets environment for procurement
 - Can dictate health and safety strategy
 - Designers take on Client's values
- Provides resources for health and safety in terms of finance and time
 - Can require contractors to do likewise

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Role of Designer

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■ Design influences on health and safety include:-

4

– Avoidance of contaminated land

– Setting of tunnel diameter

– Facilitating use of TBMs

– Specification of fire fighting, atmospheric monitoring, communications systems

5

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Other procurement issues

2

- Partnering
 - Should have benefits for health and safety

3

- Joint ventures

- Use expertise of all parties

4

- Good project management

- Includes health and safety management

5

- Role of insurance companies

Health and Safety in Tunnel Construction

1

Ground risk

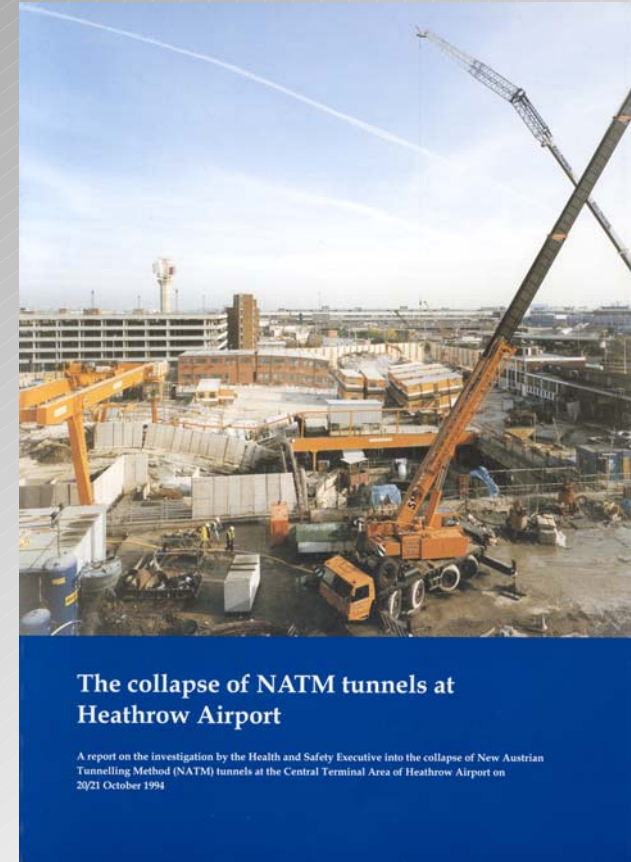
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- Risk to Client
 - Financial loss
- Risk to work force
 - Death or injury
- Risk to public
 - Death or injury
- High consequence low frequency event

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Ground risk

2

- Primary lining of fundamental importance to safety of tunnel

3

- Sequence of excavation as designed must be maintained

4

- Adherence to specification for materials and workmanship essential

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- Learn from mistakes of others



1

Ground risk

2

- Site investigation must be adequate if risk to be minimised

3

- Design must address excavation and primary support requirements

4

- Designer and Contractor should liaise

5

- Stability of permanent works

- Stability of primary lining

- Tunnel stability at all stages of construction

1

Excavation & Lining methods

2

- Soft ground
 - TBM
 - NATM or SCL
 - Hand techniques

3

- Use of TBM
 - Limits settlement
 - Speeds excavation
 - Enhances safety underground
 - May increase risk to 3rd parties



4

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Excavation & Lining methods

2

- Hard rock
 - Unshielded TBM
 - Drill & Blast

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Observational Methods

2

- Require extensive engineering input

3

- Most probable and most unlikely cases

4

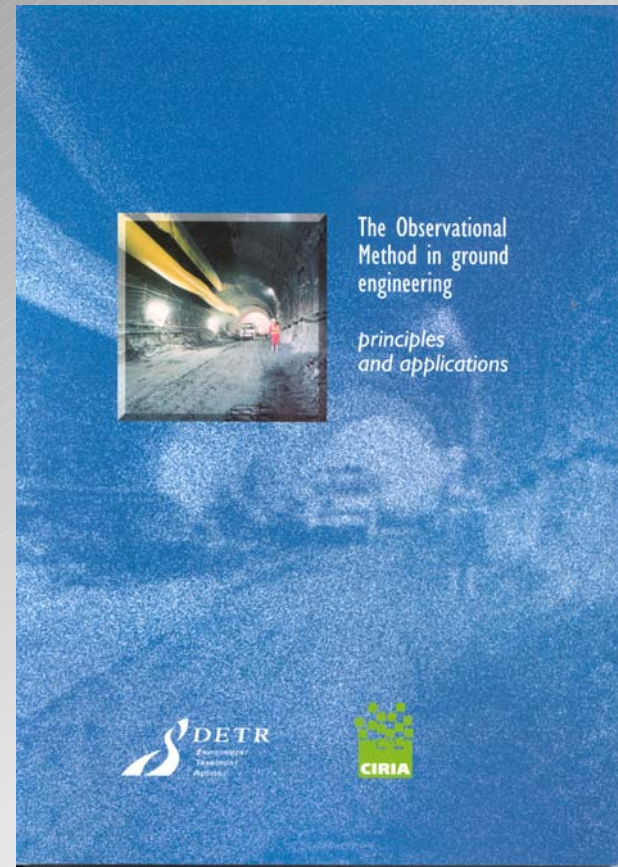
- Incremental steps

- Triggers and alarms

5

- Contingency plans

- Emergency plans



1

Machinery Safety Standards

2

- EN 815 – Unshielded TBMs

3

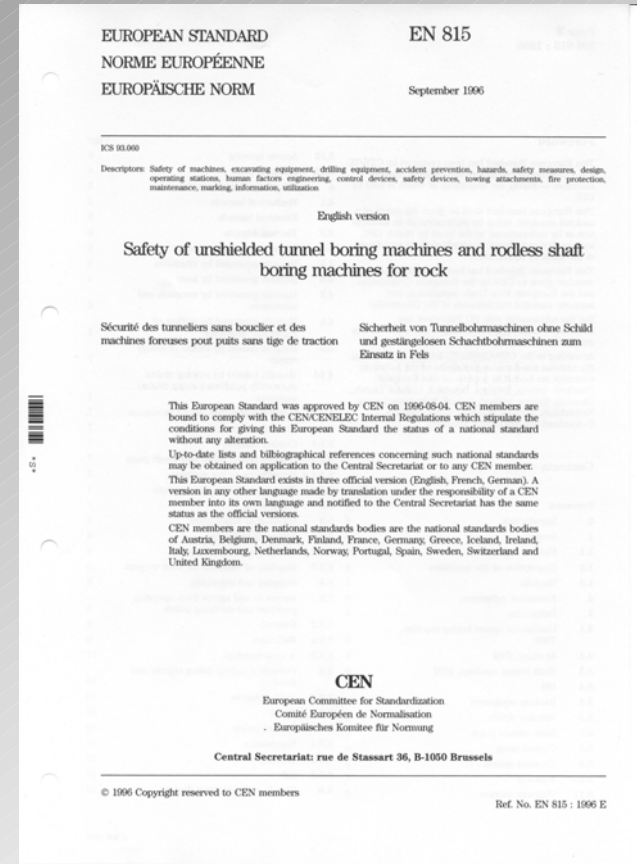
- EN 12336 – Shield machines

4

- EN 12111 – Roadheaders

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- EN 12110 - Airlocks



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Tunnel machinery hazards

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- Segment build area

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- Heavy loads
- Poor visibility

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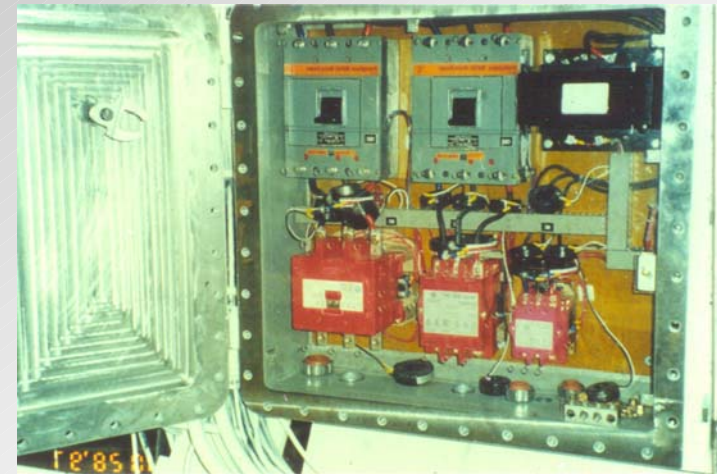
Tunnel machinery hazards

3

- Fire
- Electricity
- Control points and systems

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Tunnel machinery hazards

2

- Access to cutterhead

3

- Handling of heavy components

4

- Rotation/stability

- Walkways and access openings

5

- Visibility



1

Excavation & Lining
methods

2

- Control points and systems

3

- Hydraulic systems

- Fire

4

- Operator protection

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- Potentially explosive atmospheres



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- Explosive atmospheres
 - Explosion protection of mechanical and electrical plant when in potentially explosive atmospheres
 - ATEX Directives



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Tunnel transport systems

- Bored tunnels
 - Railway systems
 - Fuelling
 - Exhaust emissions
- Other tunnels
 - Wheeled or tracked vehicles
 - Exhaust emissions



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Tunnel transport systems

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- Visibility poor
- Driver visibility poor

3

- Separation of vehicles and pedestrians

4

- Reduce vehicle movements

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- Slurry systems
- Conveyors



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Tunnel atmosphere hazards

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- Oxygen deficiency and enrichment
- Toxic gases – CO, NO, NO₂, H₂S, NH₃, SO₂

3

- Carcinogens – Toluene, benzene, xylene
- Asphyxiant gases - CO₂

4

- Potentially explosive gases - CH₄, VOCs
- Radon

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- Dust - silica
- Heat



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Ventilation

2

- Removes contaminants

3

- Brings in fresh air

4

- Cools tunnel

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- Controls smoke

- Must be correctly positioned

- Must be maintained



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Explosives

2

- Drilling hazards

- Dust

- Noise

- Vibration

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- Premature detonation

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- Toxic fume

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- Blast shelter



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Fire, flood, rescue and escape

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- Fire + smoke = major hazard to workforce

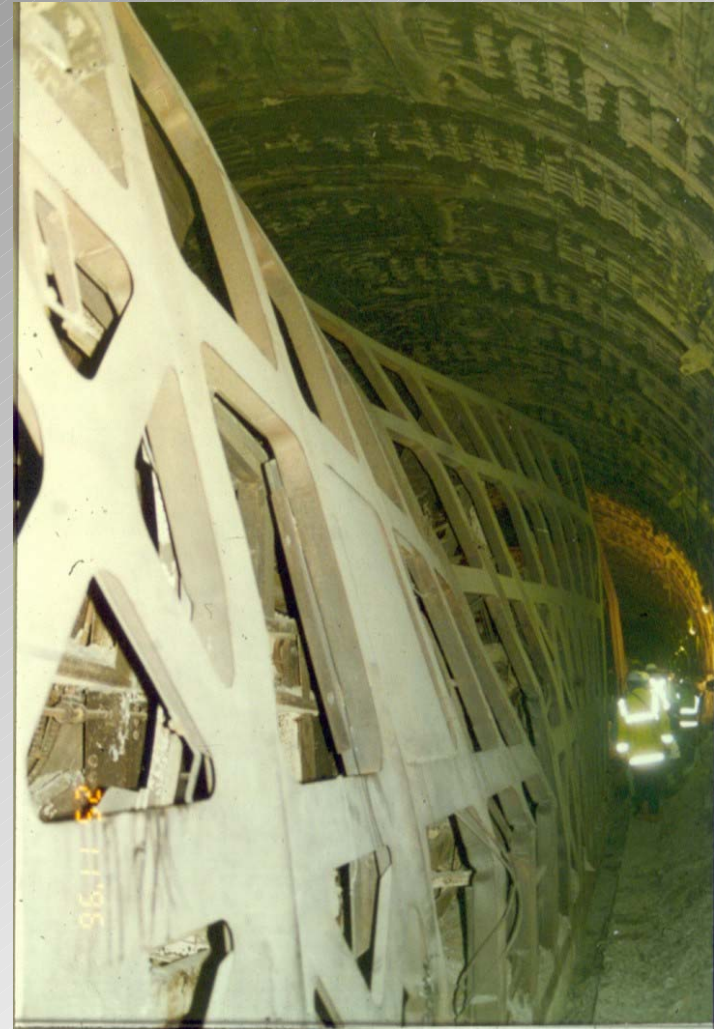
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- Fire can damage lining

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- This threatens the existence of the tunnel – a valuable asset

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Fire, flood, rescue and escape

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- Extensive flammable material underground

3

- Need for fire mitigation policy

4

- Low flammability hydraulic fluid

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- On-board fire suppression systems



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Fire, flood, rescue and escape

2

- Good housekeeping is essential

3

- Detection and alarm systems required

4

- System for accounting for personnel

5



1

Fire, flood, rescue and escape

2

- Rescue team if necessary

3

- Oxygen self rescuers for everyone underground

4

underground

5



1

Fire, flood, rescue and escape

2

- Clear walkway for escape

3

- Rescue train in long tunnels

4

- Rescue container in tunnel

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1

Work in compressed air

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- For ground stability below water table

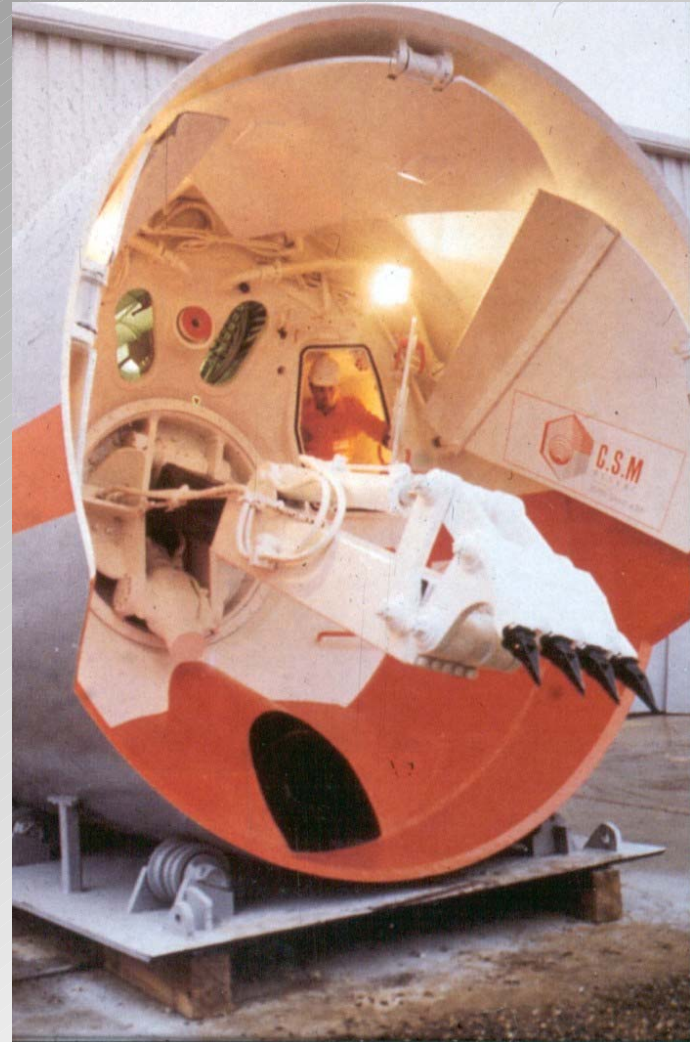
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- Essential to safe operation of certain TBM types

4

- Use of TBMs reduces numbers of exposures

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Work in compressed air

2

- Enhanced fire risk

3

- Increased mass concentration of oxygen in compressed air

4

- increased volumetric concentration if leakage/discharge of oxygen to tunnel atmosphere

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1

Work in compressed air

2

- Safe working pressure

3

- Controls and instrumentation

4

- Dimensions
- Fire protection

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- Oxygen breathing



Conclusions and references

1

This presentation has focussed on three important aspects of good tunnelling practice

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- Occupational health
- Welfare
- Safety

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In the time available it has only been possible to present an overview but more information and references can be found in my paper.

Health and Safety in Tunnel Construction

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Thank you for your
attention