Underground Mining of Metalliferous Deposits
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Lecture 60
Safety in U/G Mines-II

MAJOR OPERATIONAL HAZARD IN CAVING

ROCK BURSTS:

Rock bursts – Rock bursts have been defined classically as the uncontrolled disruption of rock associated with a violent release of energy additional to that derived from falling rock fragments.

Rock bursts may have one of two causes –

i. Unstable slip on a pre-existing plane of weakness, usually a fault.

ii. Unstable brittle fracture of intact rock.

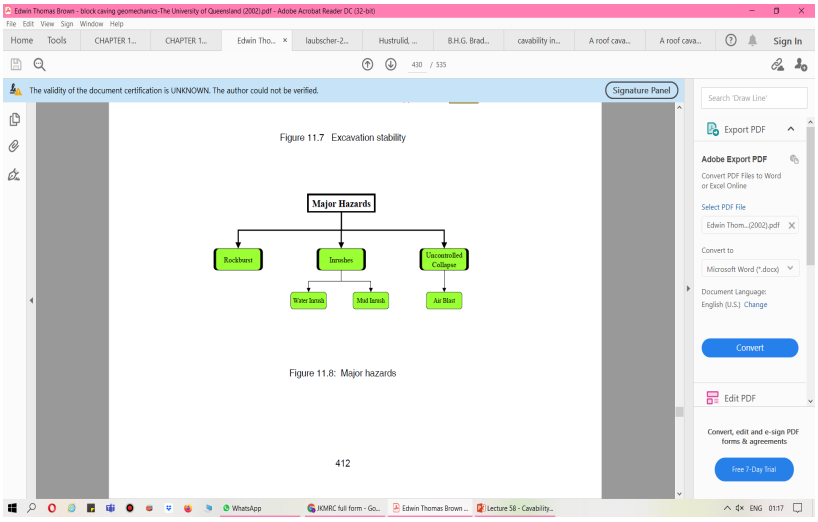

Figure 1. Major hazard

INRUSHES:

Water and slurry inrushes are those occurrences in which water and/or slurry enter the mining zone from some external source such as a water storage dam, a tailings dam or a backfilled stope.

MAJOR UNCONTROLLED COLLAPSE:

Major uncontrolled collapses will be taken to include occurrences such as:

Type 1 : Uncontrolled collapse to a mined-out overlying void.

Type 2 : Uncontrolled falls of large blocks or volumes of rock from the back of the undercut or, more usually, the cave.

Type 3 : Collapse, progressive or otherwise, of excavations on and above the extraction level.

AIR BLASTS:

An air blast is the rapid flow of air through an underground opening following compression of the air in a confined space, most frequently by the sudden fall of a large volume of rock. Commonly caused by Type 1 and Type 2 Major Collapsed.

Effects:

- Generate large amounts of dust, producing "white out" conditions and can cause eye injuries to personnel in the vicinity. People in the path of the blast can be seriously injured or even killed.
- Equipment can be overturned or picked up by the blast and destroyed, support elements and services can be ripped from the walls of excavations, shaft installations can be stripped, safety doors can be blasted away, etc.

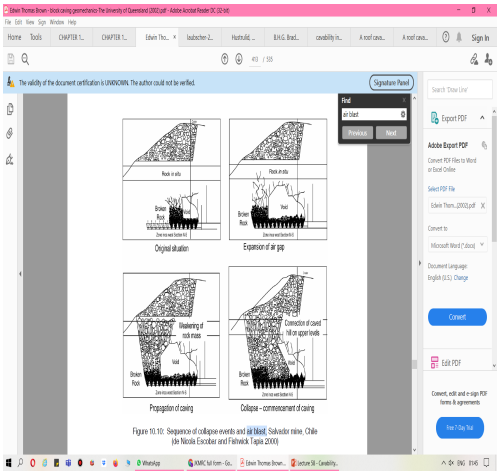

Figure 2. Sequence of collapse events and air blast, Salvador mine, Chile.

UNDERSTANDING ACCIDENT

Theories/Approaches for accident/injury Prevention

- Accident proneness theory
- Domino theory
- Loss control approach
- Cause accident result sequence
- Multiple causation theory

- Epidemiological approach
- Reason's Swiss cheese model

Accident proneness theory

A widely discussed theory in accident causation research, this theory proposes that there exists a certain sub group of the general population that is more liable to have accidents. The theory is based on certain innate personality characteristics that cause accident prone individuals to have more accidents than people who are not accident prone.

Domino theory

This theory is well known as one of the best theories of accident causation. Heinrich likened the sequence of accidents to five standing dominoes. If the first domino falls, the remaining dominoes will also fall in a particular sequence. However, if one of the dominoes is removed, the sequence of falling is broken and the end result, the last domino falling, cannot take place.

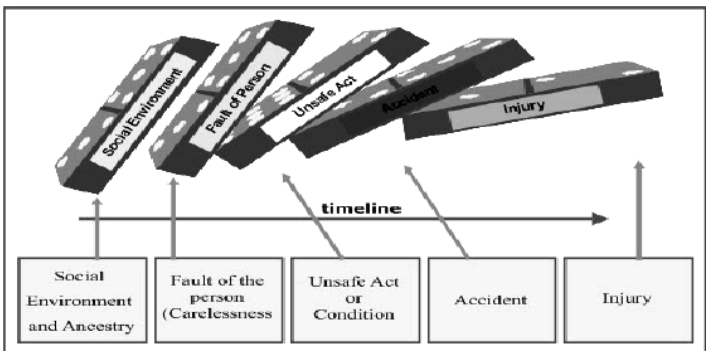

Figure 3. Domino theory

DOMINO THEORY

Bird and Loftus subsequently extended Heinrich's Domino Theory to take into account the influence of management in the accident sequence. They proposed an alternative sequence of events, thus

1.Lack of control by management, permitting

2.Basic causes, i.e. personal and job factors, leading to

3.Immediate causes, e g substandard practices, conditions or errors, which are the direct cause of

4.The accident, which results in

5.A loss, e g negligible, minor, serious or catastrophic

Loss control approach:

- Any intentional management action directed at the prevention, reduction or elimination of the pure non speculative risk of business.
- A management system designed to reduce or eliminate all aspects of accidental loss that lead to waste of an organization's assets.

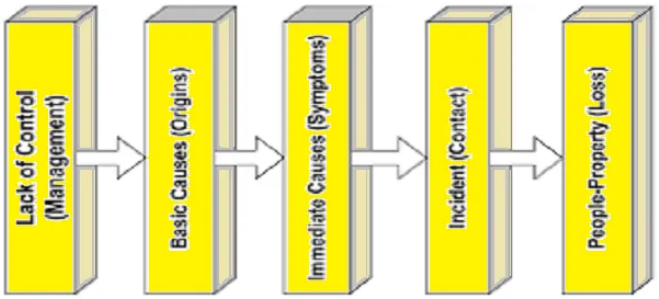

Figure 5. Domino theory(Bird and Loftus, 1976)

DIRECT AND INDIRECT CONSEQUENCES

Cause accident result sequence:

A theory of accident causation which proposes that the indirect causes of an accident (personal factors and source causes) contribute to the direct cause (unsafe acts and unsafe conditions) which result in the accident.

The accident has direct result, that is the immediate results of the accident (such as personal injury and property damage), but also indirect results, both for the injured person (such as loss of earning) and for the organization (such as poor reputation).

Multiple causation theory:

- Multiple causality means that there are more than one cause of an accident.
- There are a number of causes which contribute or lead to both the unsafe act and the unsafe conditions.
- By identifying these multiple causes, the unsafe act or unsafe condition should be prevented.

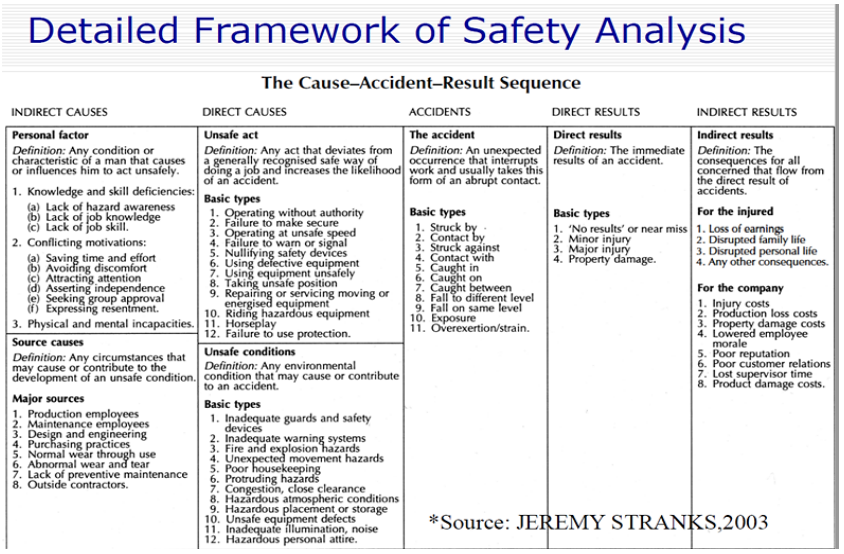

Figure 6. Detail framework of Safety Analysis.

ADVANCED APPROACHES

Epidemiological approach:

- The scientific study of the distribution of diseases and injuries in populations and identification and quantification of risk factors.
- The concepts of epidemiology provide a valuable perspective particularly with respect to reducing disease and injury in the population as a whole or in the subsets of the population.

Reason's Swiss cheese model:

- For organisational accidents, failures in the three basic elements are required:
  - Organisational processes.
  - Task and environmental conditions.
  - At the individual level a variety of errors or violations.
- These failures combined with a limited window of opportunity where the system defences that normally control the hazard are absent or failed results in the adverse outcome –an accident, incident, near miss or operational failure.
- The development of active foresight, or what Reason (1997) describes as constant vigilance on the causes of the failures, will also help to reduce accidents.

SAFETY AUDIT

As defined in ISO 19011, Audit is a 'systematic, independent and documented process for obtaining evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled'.

- Audit highlights the strength and weaknesses or deficiencies in the system and opportunities for improvement in the system
- Audits provide a basis for continual improvement.
- Audits set up a system for action to correct the immediate problem and steps to stop it happening again.

Auditing the effectiveness of the programmes within the Safety Management Plan:

An on-going process which should show whether policies, regulations and expectations are being met or where systems can be made more effective. Both internal and external audit should be considered.

- Auditors need training to be objective and independent.
- Management team or the Health and Safety committee would have to decide how often would audits be done, what system or areas would be audited and reporting arrangements.

EMERGENCY MANAGEMENT

EMERGENCY RESPONSE PLAN:

- It is an action plan to organise an employees action during workplace emergencies.
- Well developed emergency plans and proper employee training will result in fewer injuries and less structural damage to the facility during emergencies.

Emergency management process:

- ❑ Preparedness phase
- ❑ Response phase
- ❑ Recovery phase
- ❑ Mitigation phase

Preparedness phase:

Consists of activities carried out in advance before an emergency strike to improve response to emergency. e.g., hazard or risk analysis, training, drills, warning systems procedures, etc.

Response phase:

Consists of the immediate response to emergency by the Emergency Response Team. It aims at containing the disaster so as to minimise loss of life and destruction to property.

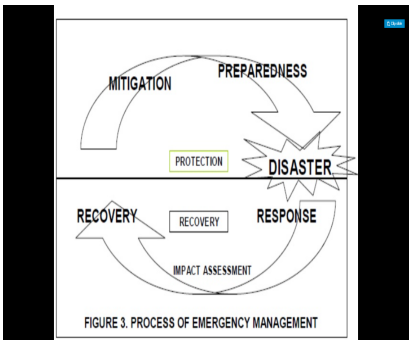

Figure 7. Process of Emergency Management.

Response phase includes measures such as -

- Notification
- Implementation of Emergency Response Plan (ERP)
- Activation of emergency operation centres
- Mobilization of resources
- Issuance of warnings and directions
- Provisions of medical and social services assistance
- Announcement of emergencies or disasters by the management

Recovery phase:

It refers to those measures undertaken following a disaster that will return all system to normal levels of service. It includes measures such as-physical restoration and reconstruction, cleaning up containment areas, eliminate and/or reducing any known hazards, restoring business.

Mitigation phase:

It is the continuous ongoing endeavour to avert or reduce the impact that a hazardous materials incident will have on people, property, and the environment e.g., hazard identification, risk analysis, etc.

PROBLEMS and SOLUTIONS

Ex-1: Calculate (a) Frequency Rate(F.R.); (b) Severity Rate (S.R.); (c) Injury Index (I.I.); (d) Average days charged per accident using the following data:

No of workers per shift = 300

No of hours worked per shift = 8

No of shift = 3

Number of days worked = 300

No of accident = 18

No. of Mandays lost = 11

Solution:

Average Man-hours worked = Number of workers per shift × Hours worked per shift× No of shifts in a day ×Number of days worked in a year

$= 300 \times 8 \times 3 \times 300$

$= 2160000$

$$(a)\ Frequency\ Rate\ (F.R.) = \frac{No\ of\ accidents\ \times\ 10^6}{Man\ hours\ worked}$$

$$= \frac{18 \times 10^6}{2160000} \frac{18 \times 10^6}{2160000}$$

$= 8.33$

(b) Severity Rate (S.R.) = (No. of Mandays lost $\times\times 10^6$)

(Man Hrs. Worked)

$$= \frac{11 \times 10^6}{2160000} \frac{11 \times 10^6}{2160000}$$

$= 5.09$

(c) Injury Index (I.I.) $= \frac{\text{(F.R.} \times \times \text{S.R.)}}{\textbf{(1000)}}$

$$= \frac{8.33 \times 5.09}{1000} \frac{8.33 \times 5.09}{1000}$$

$= 0.04$

(d) $= \frac{\textbf{Average days charged/Accident}}{\textbf{(F.R.)}} \frac{\textbf{Average days charged/Accident}}{\textbf{(S.R)}}$

$$= \frac{5.09}{8.33} \frac{5.09}{8.33} = 0.61$$