Underground Mining of Metalliferous Deposits
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Lecture 38
Pillar Failure

STRESS DISTRIBUTION

- Stoping activity in an ore body causes stress redistribution and an increase in pillar loading.
- Stresses are higher at excavation boundaries than in the center of pillars.

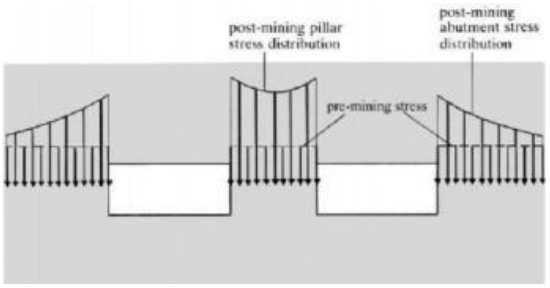


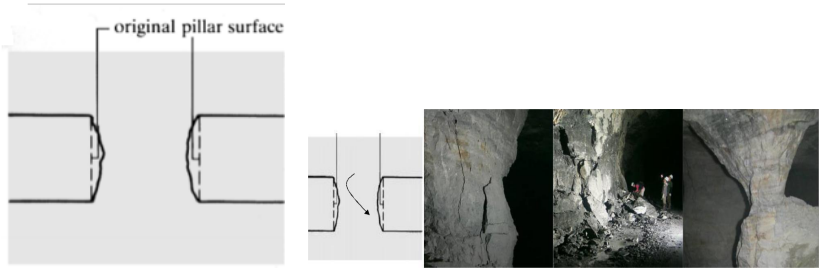
Figure 1. Redistribution of stress in underground mining

Modes of failure

1) Fretting/necking/spalling
2) Shear failure
3) Axial Splitting (Bulging or barrelling)
4) Structural failure
5) Buckling of Pillars

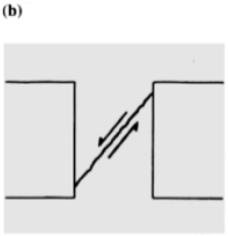
1. Fretting/necking/spalling/hour-glassing

- Fretting occurs in massive rock with moderately strong H/W, F/W, and ore body.
- One of the main causes for necking is development of tri-axial stress condition at the wall contacts (H/W and F/W).
- The failure is due to **tensile stress concentration.**
- The failure is localised in the central part of the pillar.



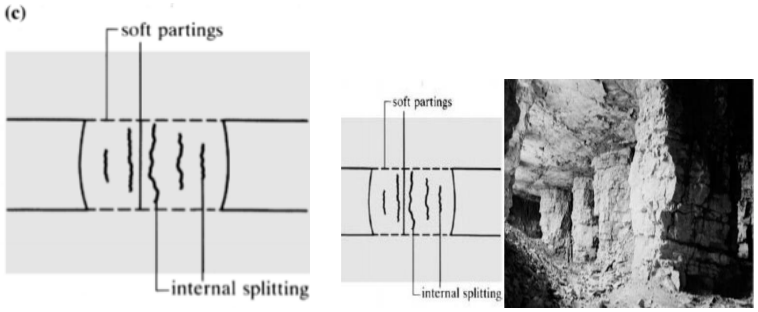
2. Shear failure

- For regularly jointed rock, a high pillar height/width ratio may favour the formation of inclined shear fractures dividing the pillar across plane of weakness.
- There are kinematic factors promoting the development of penetrative, localized shear zones of this type.



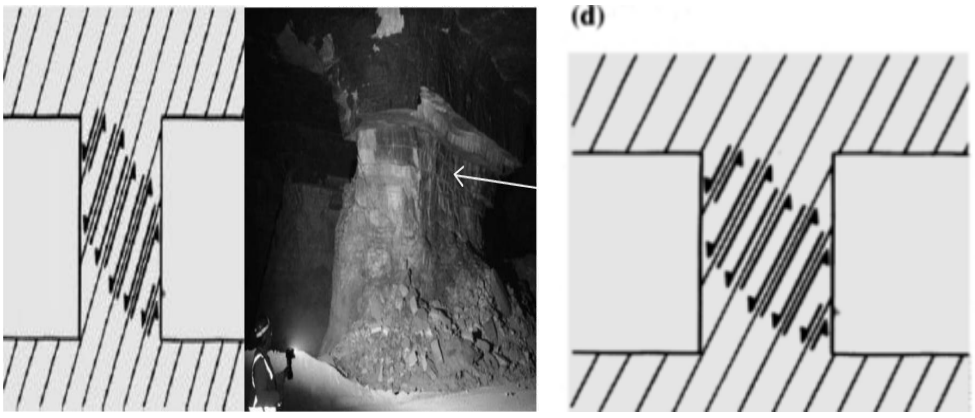
3. Axial Splitting (Bulging or barreling)

- Occurs in relatively strong ore body as compared to the wall rocks and hang-wall rocks.
- Highly deformable plane of weakness at the contact plane of the pillars.
- Relative deformation of the pillar and the hang-wall rocks generates transverse tractions over the pillar end surfaces.
- Promotes internal axial splitting of the pillar/ lateral bulging or barreling of the pillar surfaces



4. Structural failure

- This mode of failure is commonly seen in layered ore bodies, such as limestone or banded hematite quartzite (BHQ).
- A pillar with a set of natural fractures or bedding planes forms the weak planes for the fracture initiation along these planes of weakness.
- The failure is similar to the shear failure, where in slip takes place when the shearing stress on these planes is more than the frictional resistance.

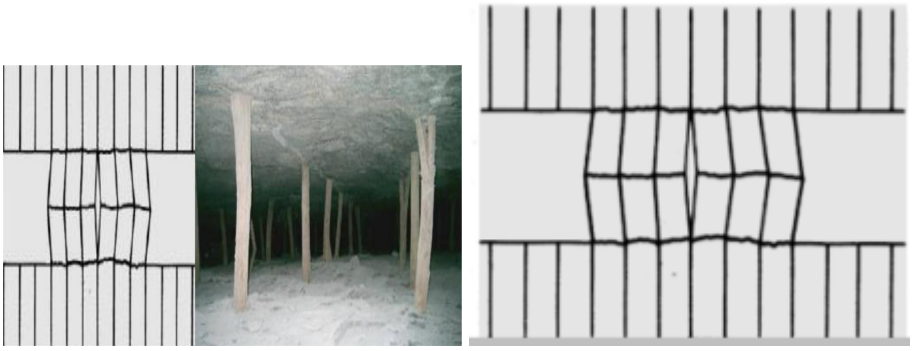


5. Buckling of Pillars

a. This is common in slender pillars, where width/height ratio of the pillars is very less (0.4 - 0.5).

b. A slender pillar with well-developed foliation or schistosity parallel to the principal axis of loading will fail in buckling mode.

(e)



6. Foundation Failure

- If the foundation rock is of low strength, it could fail prior to failure of the pillar itself.
- Pillar foundation can be in the hanging wall or footwall of sill pillars in steeply dipping deposits.
- Numerical analysis is done to determine potential for foundation failure.

Progressive failure

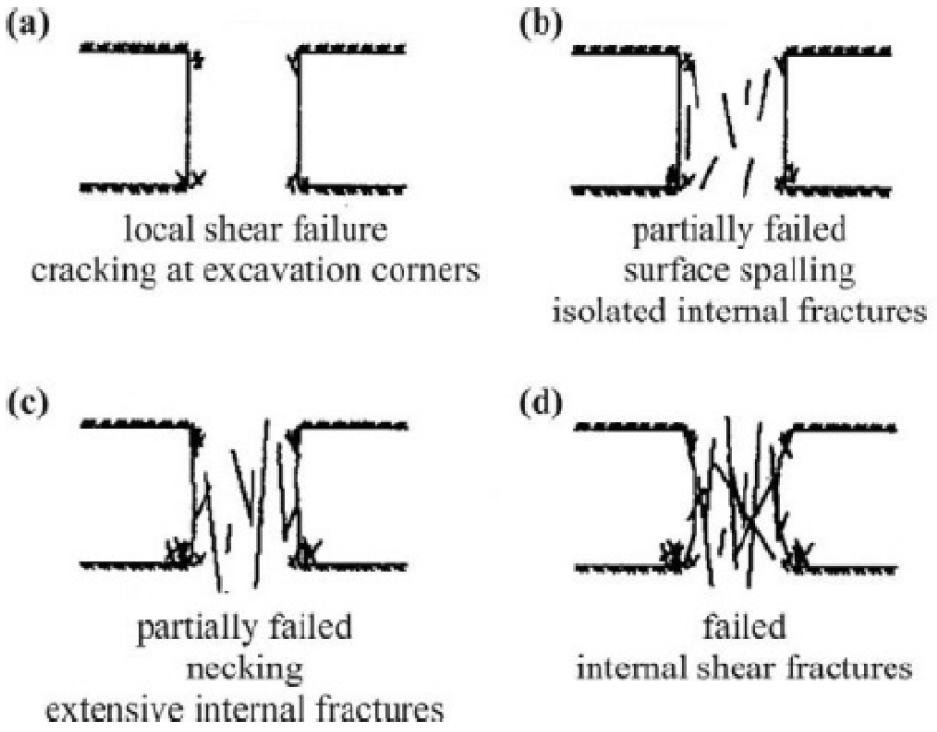


Figure 2. Schematic illustration of the evolution of fracture and failure in a pillar in massive rock (after Lunder and Pakalnis, 1997).

Cascading pillar failure(CPF)

- CPF occurs when one pillar fails suddenly, which then over-stresses the neighboring pillars causing them to fail in rapid successions.
- Very large mining areas can collapse within seconds without prior warning.
- Once the cascading pillar failure has initiated, it becomes self-propagating.
- Violent air blast might disrupt the ventilation network

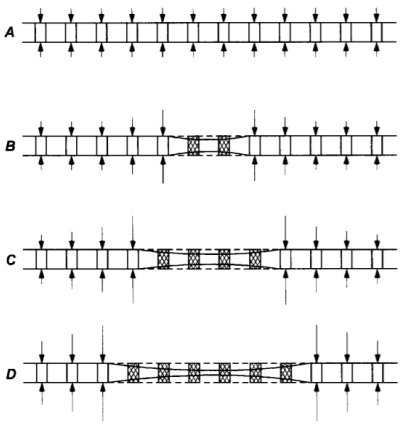


Figure3. Cascading pillar failure

Post Pillars

- ❑ Post pillars are used in cut-and-fill mining and they provide immediate support to the roof while enabling reasonably high extraction ratio.
- ❑ Post pillars are designed to fail gradually with increasing height.
- ❑ Pillar must be stable in the first cut and gradually show signs of deterioration in the second and third cut.
- ❑ In very difficult ground, post pillars may be designed as ribs with cross-cuts slashed later to produce square pillars.

MEASURES TO CONTROL THE PILLAR FAILURE

- ❖ Careful planning and design of stope based on geotechnical studies
- ❖ Back filling the stope, the fill material surrounding a pillar may act as a confining material and hence prevents the failure of the pillars.
- ❖ Rock bolting or lacing the pillar.
- ❖ High Factor of Safety for pillars.