# THE CHALLENGES OF ROCK MICROTUNNELING

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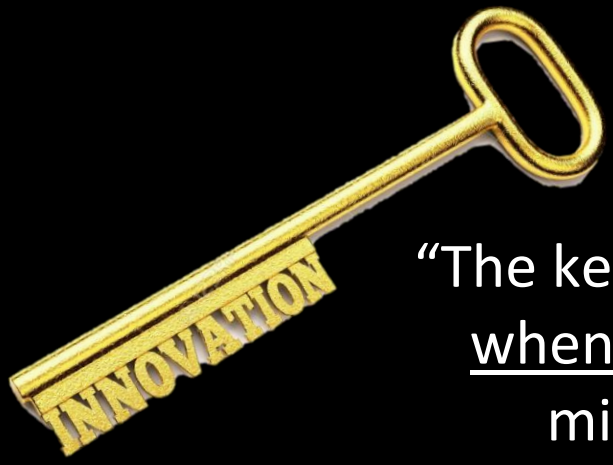
# THE CHALLENGES OF ROCK MICROTUNNELING

- **From a Contractor's Perspective**
- **Bradshaw's Experience**
  - 54 years as a tunneling contractor
  - 26 years as a microtunneling contractor
  - 25 years using conventional rock TBMs
  - 13 years microtunneling rock

# THE CHALLENGES OF ROCK MICROTUNNELING

**A continuation of my 2013 presentation of "Microtunneling in Rock: Fact or Fiction"**




"The key then and now is to know when, where, and how to use microtunneling in these challenging ground conditions."

# THE CHALLENGES OF ROCK MICROTUNNELING

## 2013 to 2017

- What have we done?
- What have we learned?
- Where do we stand?

# THE CHALLENGES OF ROCK MICROTUNNELING

## What have we done?

- 10 projects in 6 states (FL to TX to PA)
- 15 rock microtunnel drives
  - 11 Two pass steel casing
  - 4 One pass Hobas pipe
- Totaling 7,000+ LF

# KEYS TO SUCCESSFUL ROCK MICROTUNNELING

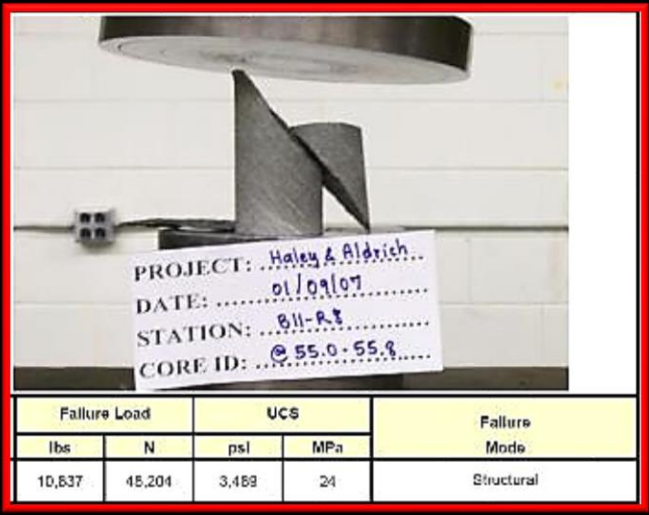
- Understand the geology
- Understand the limitations
  - Microtunneling Equipment
  - Jacking Pipe Materials
  - Microtunneling Means & Methods

# UNDERSTAND THE GEOLOGY

- Start with bid documents
- Review the Geotechnical Study
- Your goal is to understand the behavior of the ground

# GEOTECHNICAL STUDY SHOULD INCLUDE

- Type of rock by drive and within drive length
- Location of any transition zones in each drive
- Orientation & spacing of rock fractures/bedding
- Unconfined Compressive Strength (UCS) with structural or non-structural failure notation for every test



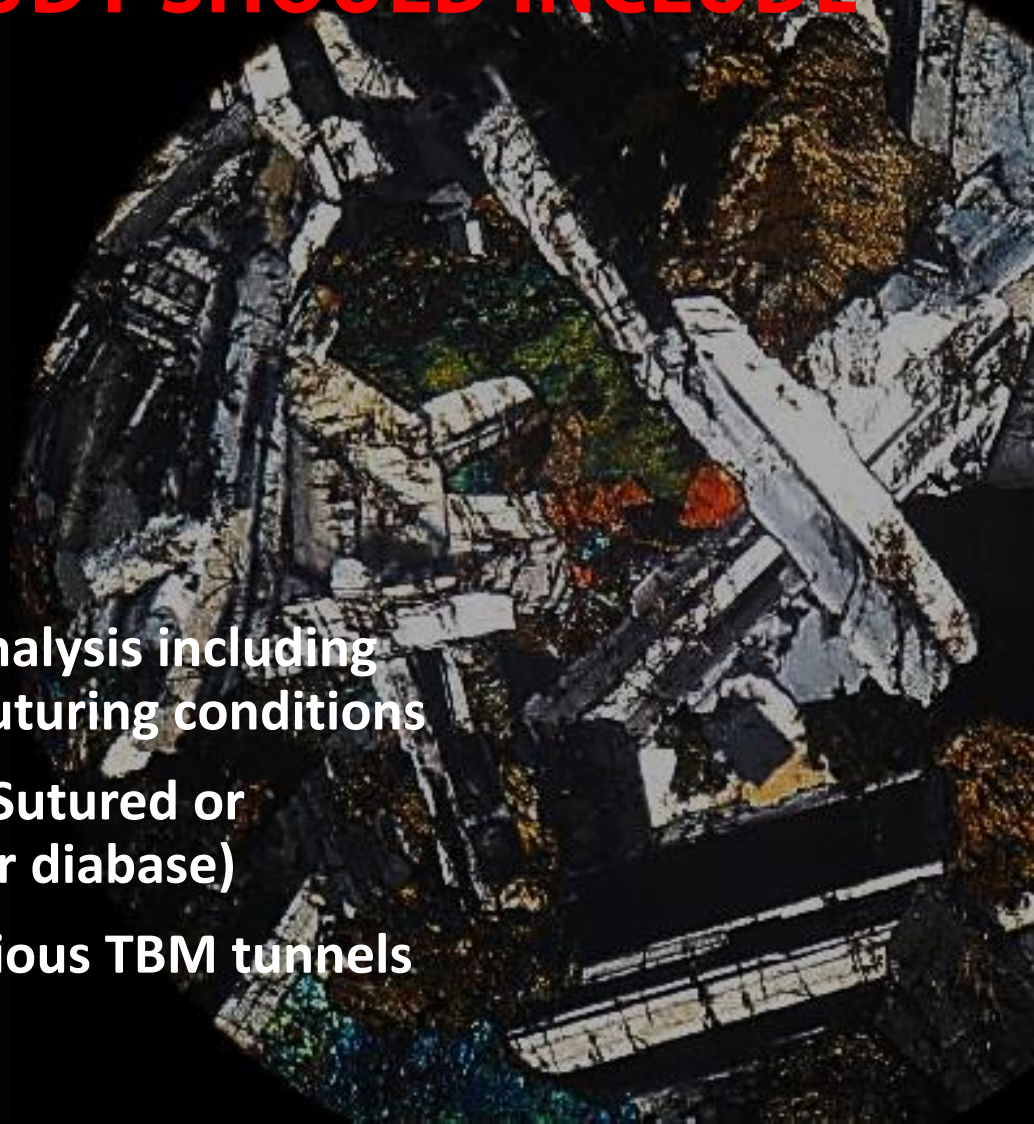

| Failure Load | | UCS | | Failure Mode |
|---|---|---|---|---|
| lbs | N | psi | MPa | |
| 10,837 | 48,204 | 3,489 | 24 | Structural |

Structural = 3,489 psi


| Failure Load | | UCS | | Failure Mode |
|---|---|---|---|---|
| lbs | N | psi | MPa | |
| 51,304 | 228,209 | 16,503 | 114 | Non-Structural |

Non-Structural = 16,503 psi

# GEOTECHNICAL STUDY SHOULD INCLUDE



- RQD (%)
- Recovery (%)
- Cerchar Abrasivity Index
- Brazilian Tensile Strength
- Point Load Test
- Punch Penetration Test
- Thin Section Petrographic Analysis including description of any mineral suturing conditions
- Take note of unusual rock – Sutured or "Tough" (e.g. amphibolite or diabase)
- Historical research into previous TBM tunnels in the area

# IMPACT OF ROCK GEOLOGY

- **Sedimentary Rock Formations**
  - Often "ideal" microtunneling ground
  - Exceptions:
    - Sandstone abrasivity - cutter wear
    - Limestone solution channels - steering
    - Decomposed layers - friction

# IMPACT OF ROCK GEOLOGY

- **Igneous (Quartzite) Rock Formations**
  - Rarely “ideal” microtunneling ground
  - Often weathered in the tunnel profile
  - Often mixed face & mixed reach drives
  - Can be extremely hard (>20 ksi UCS)
  - Can be massive (RQD>75%)
  - Can be extremely abrasive (Cerchar>3.5)
  - Can be sutured limiting disk cutter effectiveness

# EQUIPMENT LIMITATIONS

- Face access only in MTBMs >59” OD
- Disk Cutters limitations
  - Typically 11” diameter or smaller
  - Limited thrust (11”-17,000# vs 17”-70,000#)
  - Difficult to change in MTBM chamber
  - Disk cutters can break & hardware can fall out
- Slurry Separation System Impacts
  - Slurry lines can clog on rock chips
  - High wear on slurry lines, pumps & shaker screens

# EQUIPMENT LIMITATIONS

## MTBM slow compared to conventional TBM

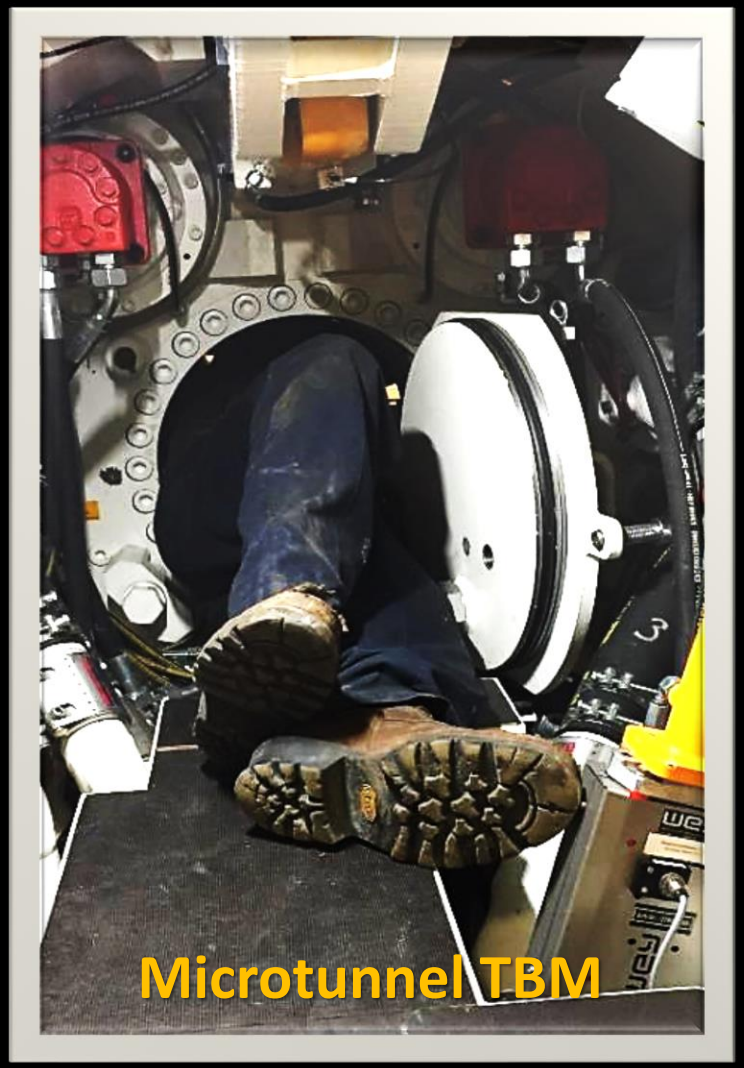
- Revolution per minute (RPM) slower (2.5-7.5 vs 10-15)
- Thrust is lower reducing penetration/revolution
- Torque capacity lower
- Checking/changing disk cutters slower

**Formula for TBM Production/shift =**

**RPM x Penetration/Revolution x % Mining Time/Shift**

**Typically 20% to 40% of Conventional TBM**

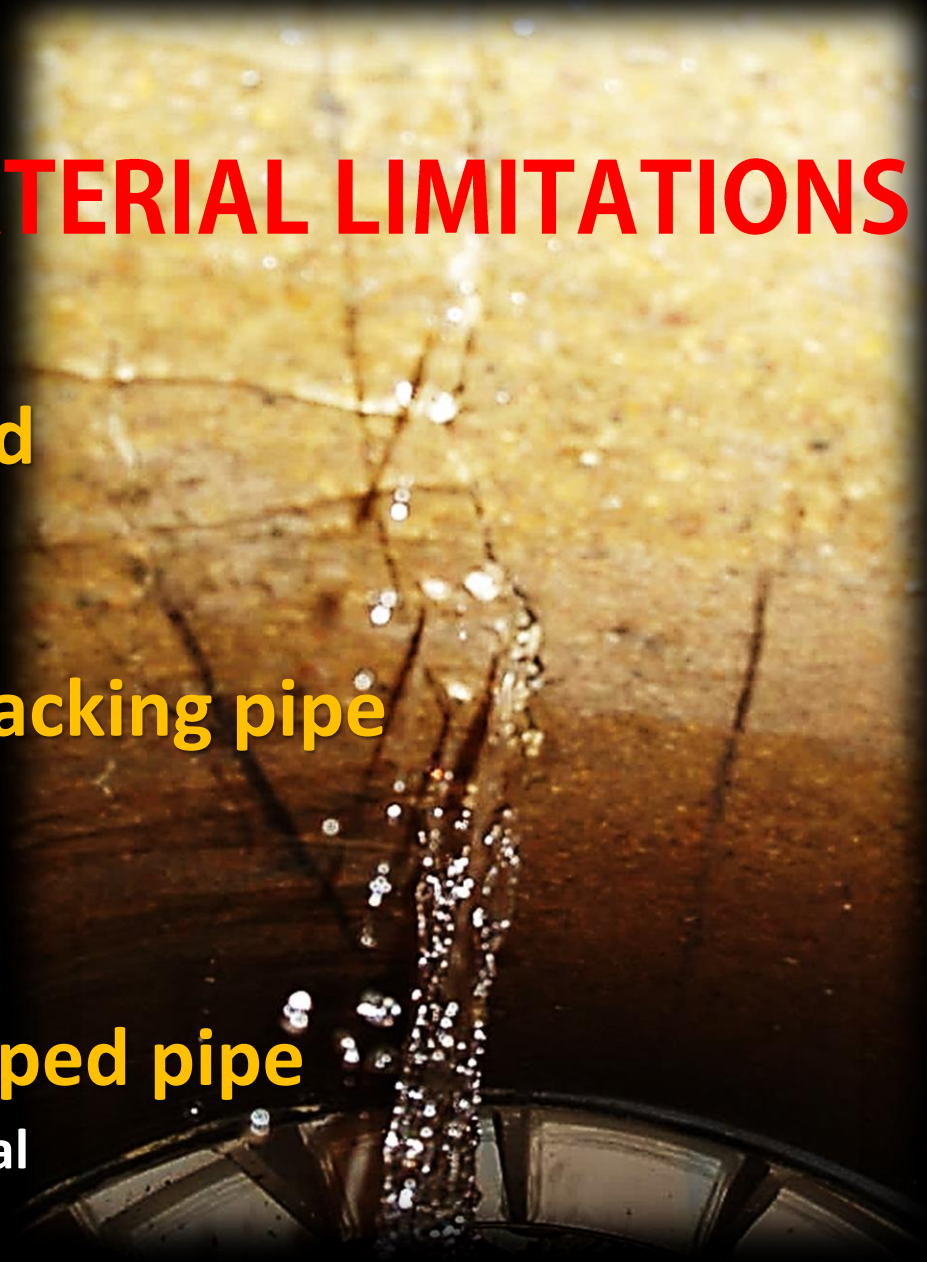
# CHANGING DISK CUTTERS COMPARISON

# CHANGING DISK CUTTERS

. . . while microtunneling . . .

# JACKING PIPE MATERIAL LIMITATIONS

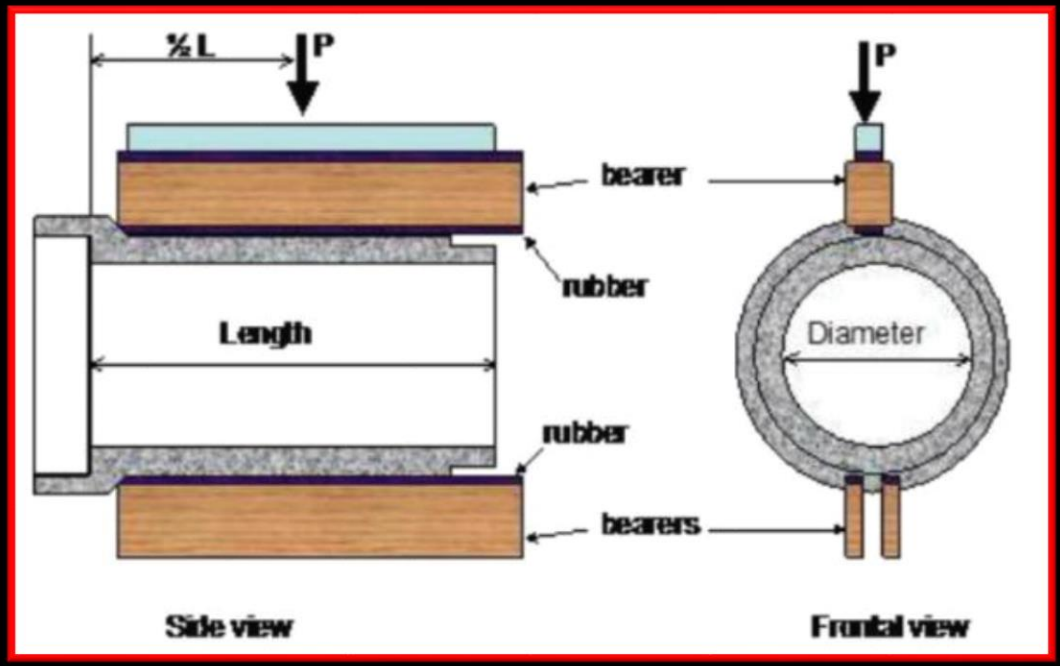


- Steel casing preferred
  - Permalok joint flexibility
  - Avoid welded joints
- Avoid unreinforced jacking pipe
  - Clay
  - Polycrete
  - Fiberglass
- Avoid irregularly shaped pipe
  - Out of round or trapezoidal

# PIPE MATERIAL LIMITATIONS

## Reason for avoiding unreinforced jacking pipe:

- Debris piles up in the annulus under the pipe with drive distance creating three edge bearing type failure

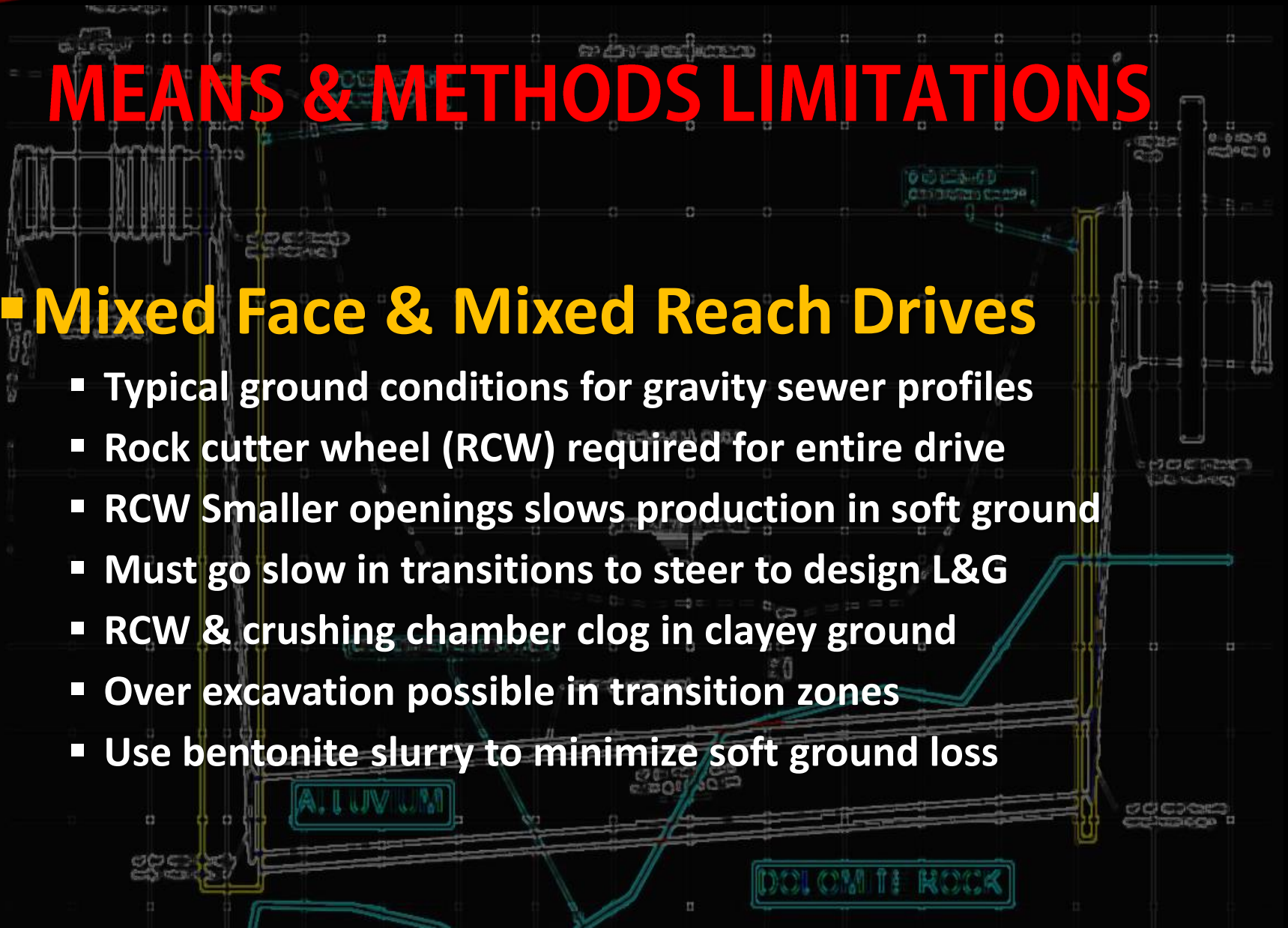


# MEANS & METHODS LIMITATIONS

- Two pass preferred
- Overcut typically double
  - Allow for gage cutter wear
  - Allow for debris pile up in annulus invert
- Max drive length less than soft ground
- Interjack stations needed even with steel casing

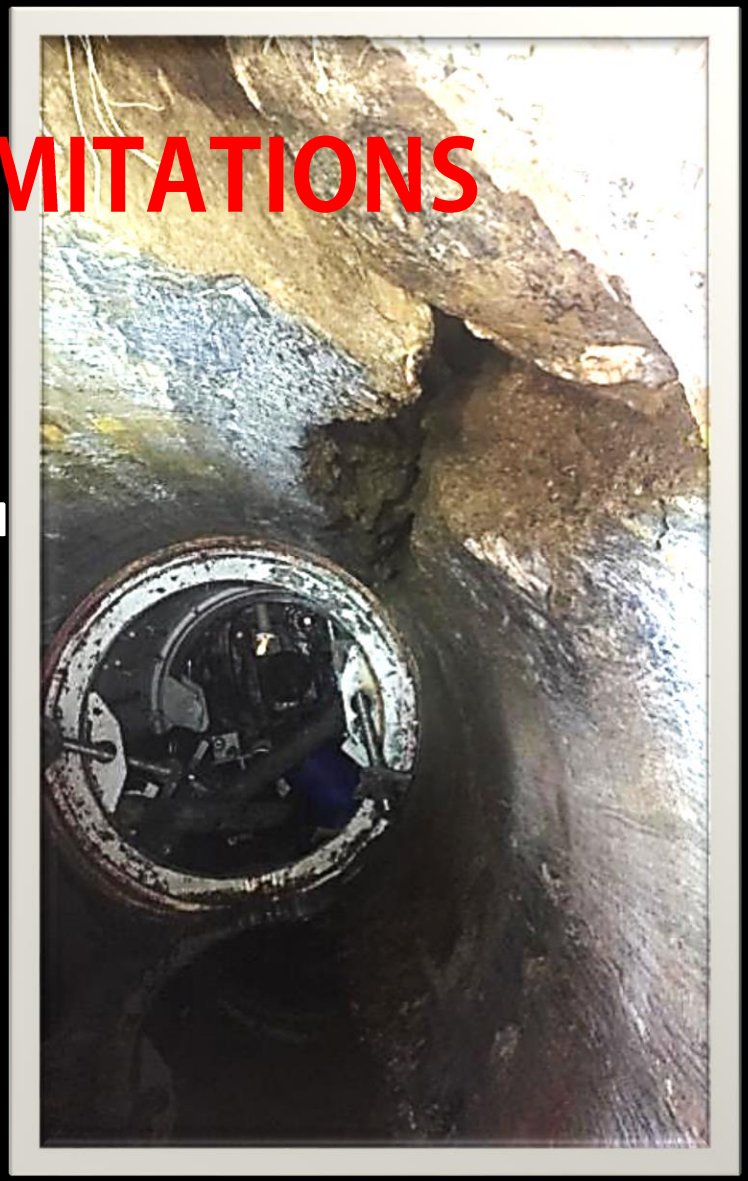
# MEANS & METHODS LIMITATIONS

- **Mixed Face & Mixed Reach Drives**
  - Typical ground conditions for gravity sewer profiles
  - Rock cutter wheel (RCW) required for entire drive
  - RCW Smaller openings slows production in soft ground
  - Must go slow in transitions to steer to design L&G
  - RCW & crushing chamber clog in clayey ground
  - Over excavation possible in transition zones
  - Use bentonite slurry to minimize soft ground loss



# MEANS & METHODS LIMITATIONS

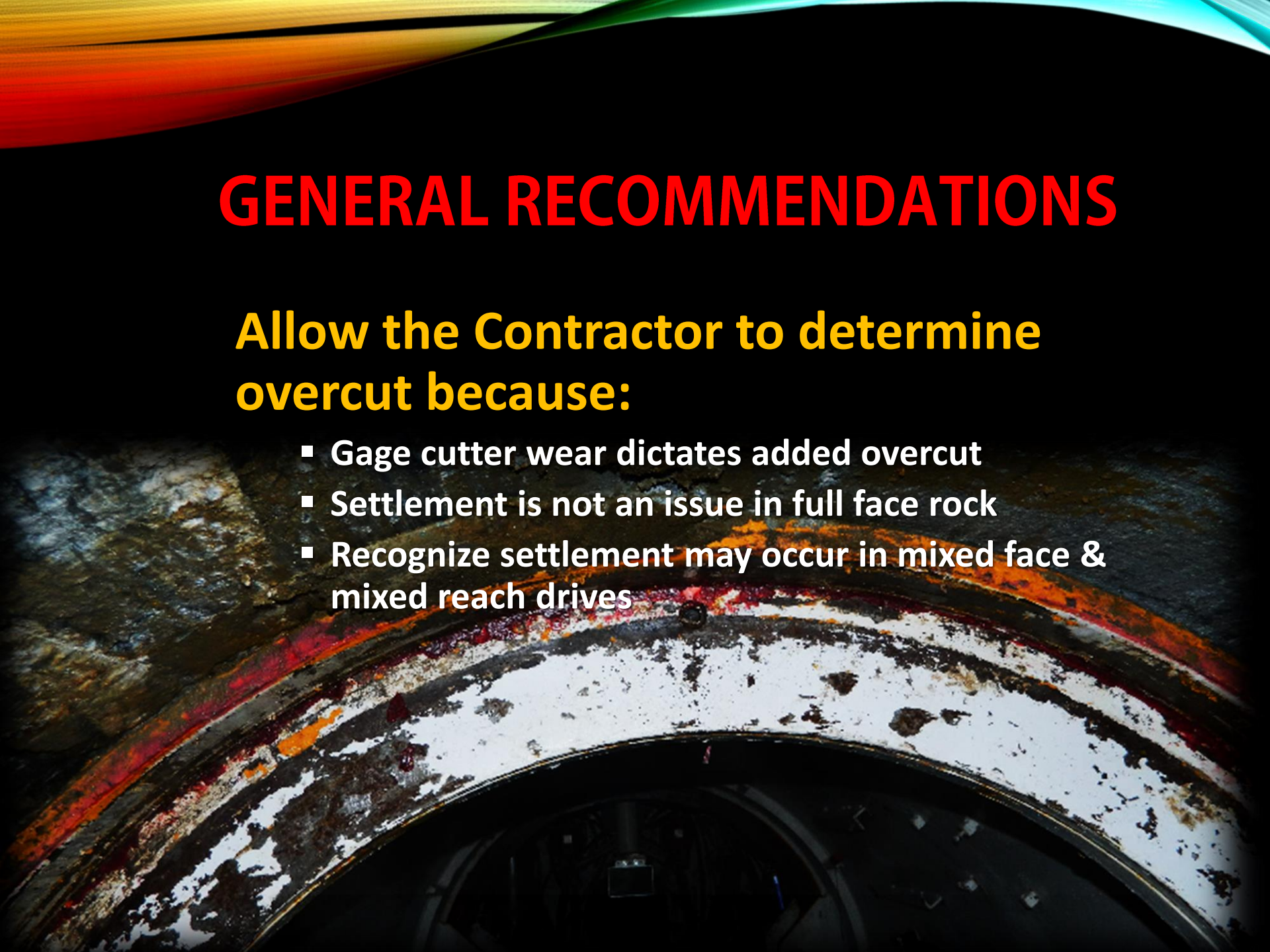
- **Cam Locking**
  - Causes pipe surges & shock loading of disk cutters
  - Use telescopic tail can to isolate MTBM
- **Pipe Wedging**
  - Rock will not yield to debris in annulus
  - Debris comes from
    - Slurry cuttings
    - Tunnel arch fall out
    - Seams in weathered rock
    - Broken disk cutters and hardware



# GENERAL RECOMMENDATIONS

- **Friction Control**
  - Set overcut to twice soft ground
  - Inspect cutting tools regularly
  - Maintain gage cutter
  - Maintain MTBM scraper buckets & wear ring
  - Account for broken hardware & disk cutters
  - Use bentonite in the slurry
  - Use polymer lubricate in the annulus

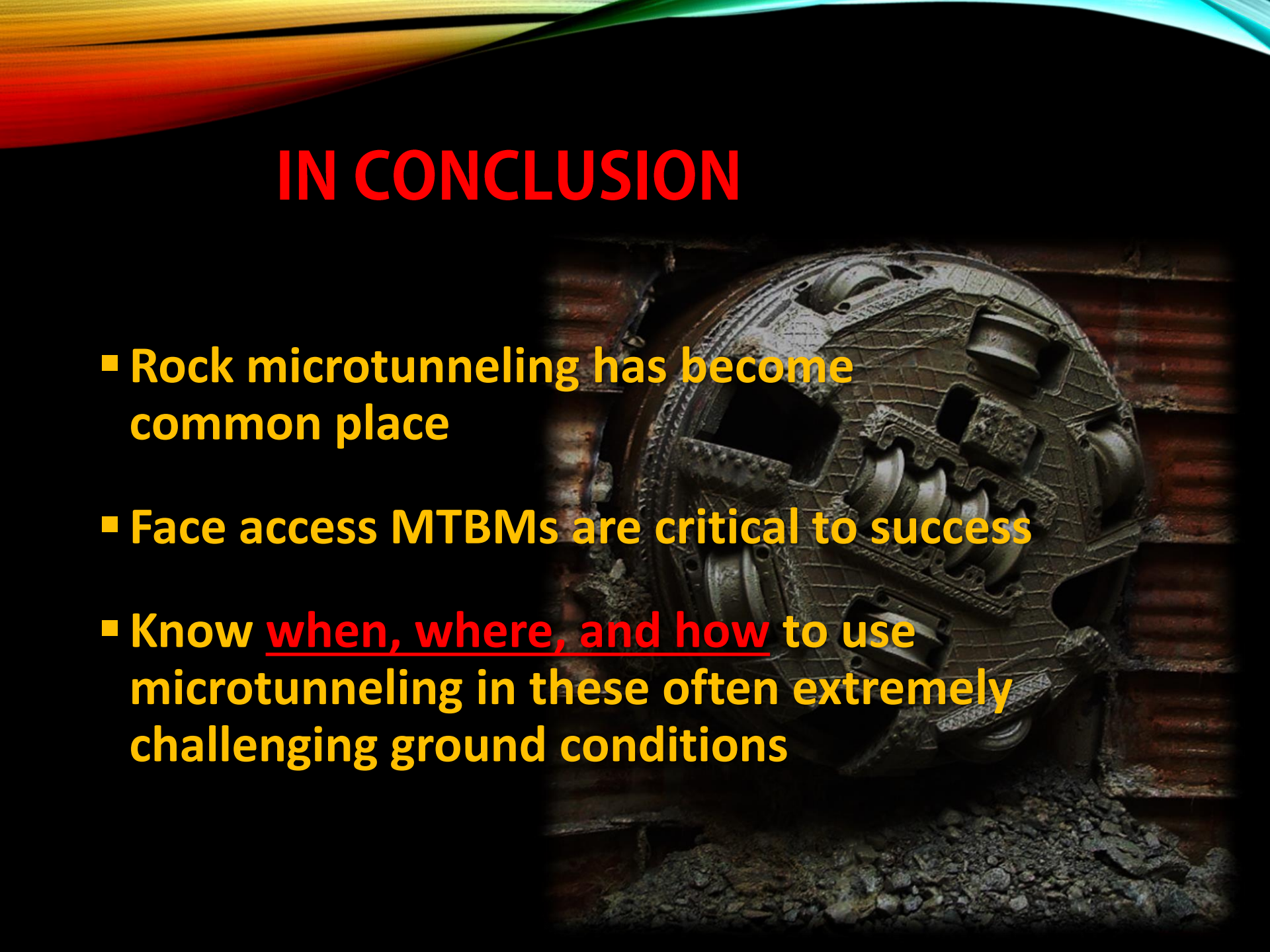
# GENERAL RECOMMENDATIONS



## Allow the Contractor to determine overcut because:

- Gage cutter wear dictates added overcut
- Settlement is not an issue in full face rock
- Recognize settlement may occur in mixed face & mixed reach drives

# IN CONCLUSION



- Rock microtunneling has become common place
- Face access MTBMs are critical to success
- Know when, where, and how to use microtunneling in these often extremely challenging ground conditions


QUESTIONS?
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