A practical design approach for an improved resin anchored tendon

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Contents

- Introduction
- Laboratory & Underground Testing
- Conclusion
• Resin bolts widely used
• Application constrained by:
  • Bar diameter
  • Hole diameter
  • Bolt geometry
  • Installation method
Introduction
Resin Annulus

- Resin annulus affects
  - Mixing efficiency
  - Gloving
  - Resin strength
• Annulus usually 2 – 4 mm
• Ø34 support bits common with hand helds
• Holes range 32 – 37 mm
• Ø25 mm bar meets annulus limits

Introduction
Application in hard rock mines

(Crompton 2007)
Benchmarking
SEPT: Ø20 mm bar in Ø38 mm hole

Ø20 mm Deformed Bar, Ø38 mm hole, 250 mm bond

Load (kN)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Displacement (mm)
Sample 1 Sample 2 Sample 3 Sample 4
Benchmarking
SEPT: Ø20 mm bar in Ø38 mm hole

Ø20 mm Deformed Bar, Ø38 mm hole, 250 mm bond
Benchmarking
SEPT: Ø20 mm bolts in Ø38 mm hole
Benchmarking

Benchmarking Performance : Ø20 mm bar in Ø35 mm hole
Benchmarking

Benchmarking Performance: Ø20 mm bar in Ø35 mm hole
Objective

“How to improve the performance and reliability of resin bolts for airleg installation in larger diameter support holes?”

In typical installation can we improve:

- Reliability
- Support capacity
- Corrosion protection (water and rock)
Objective

Identified three parameters for improvement:
- Centralisation
- Resin mix
- Resin fill
Conventional tips
Prevalent eccentricity
Laboratory Testing
Centralisation
Laboratory Testing
Centralisation
Laboratory Testing
Centralisation

Improved concentricity
Laboratory Testing

Resin mix

Improved
- Shredding
- Mixing
- Support capacity
Laboratory Testing

Resin fill

- Rotation of modified bolts creates voids
Laboratory Testing

Resin fill

Rotation creates voids
Axial flow fills voids

Ø20 mm HelixBolt, Ø38 mm hole
Laboratory Testing

Qualitative improvements: Ø18 mm HelixBolt in 35mm hole
Laboratory Testing

Qualitative improvements: deformed bar vs HelixBolt
Laboratory Testing
Laboratory SEPT- Internal

Laboratory SEPT Ø38 mm hole, 250 mm bond

Load (kN)

0 20 40 60 80 100 120 140

Resin Bond Displacement (mm)

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

Ø16 mm HelixBolt - Mean
Ø16 mm HelixBolt - 90% Limit
Ø18 mm HelixBolt - Mean
Ø18 mm HelixBolt - 90% Limit
Ø20 mm HelixBolt - Mean
Ø20 mm HelixBolt - 90% Limit
Ø16 mm HelixBolt - Mean
Ø18 mm HelixBolt - Mean
Ø20 mm HelixBolt - Mean
Ø20 mm deformed bar - mean
Underground Testing
3rd Party Laboratory SEPT

HelixBolt Underground SEPT, Ø35 mm hole

Load (kN) vs. Resin Bond Displacement (mm)

- Ø16 mm HelixBolt - Mean
- Ø16 mm HelixBolt - 90% lower limit
- Ø18 mm HelixBolt - Mean
- Ø18 mm HelixBolt - 90% Lower Limit
- Ø20 mm HelixBolt - Mean
- Ø20 mm HelixBolt - Lower Limit
Conclusion

- Identified parameters to improve resin bolt performance
- Iterative design, testing and validation
- Outcomes implemented in various products
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