Rockbolts in Shear

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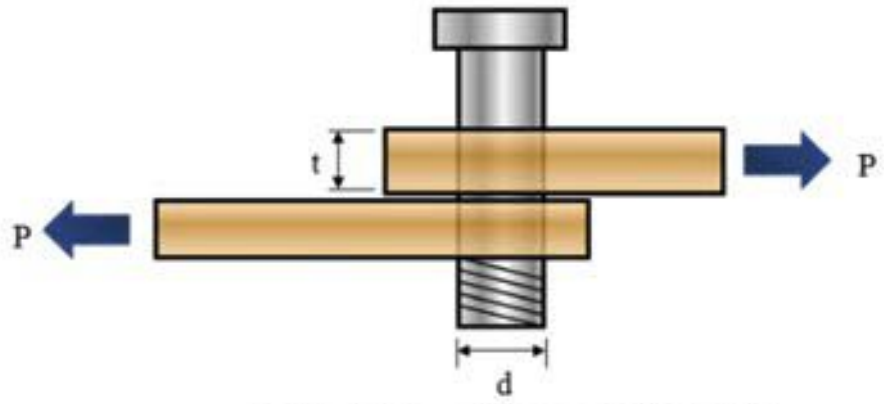
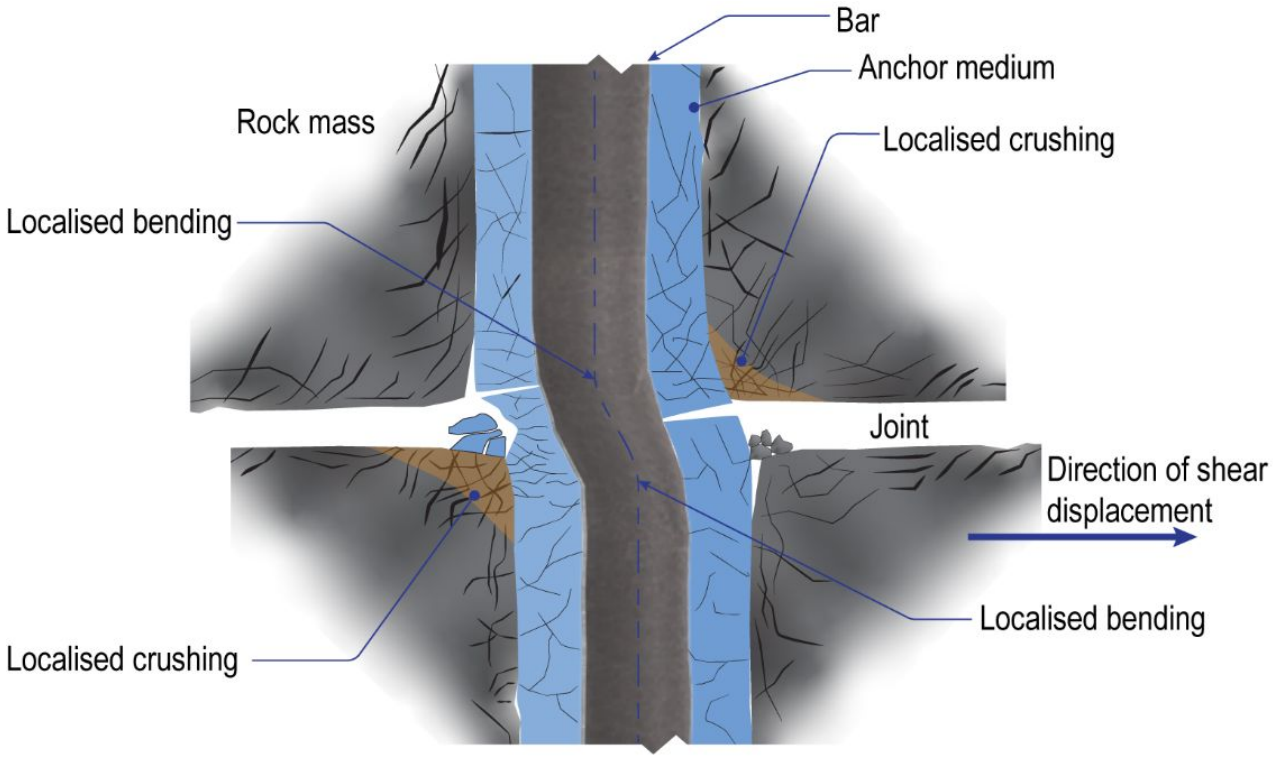
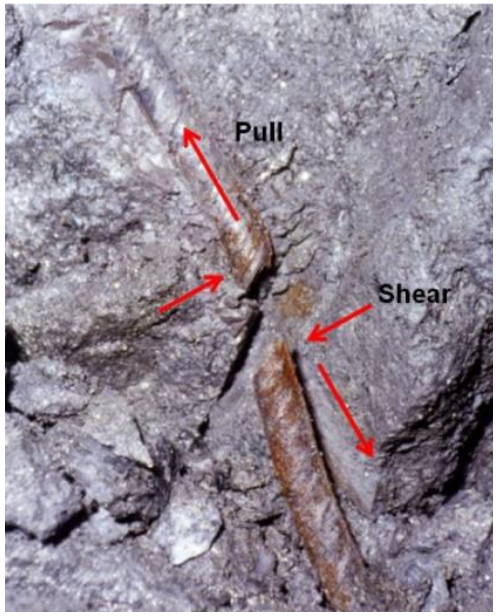
Shear loading of rockbolts

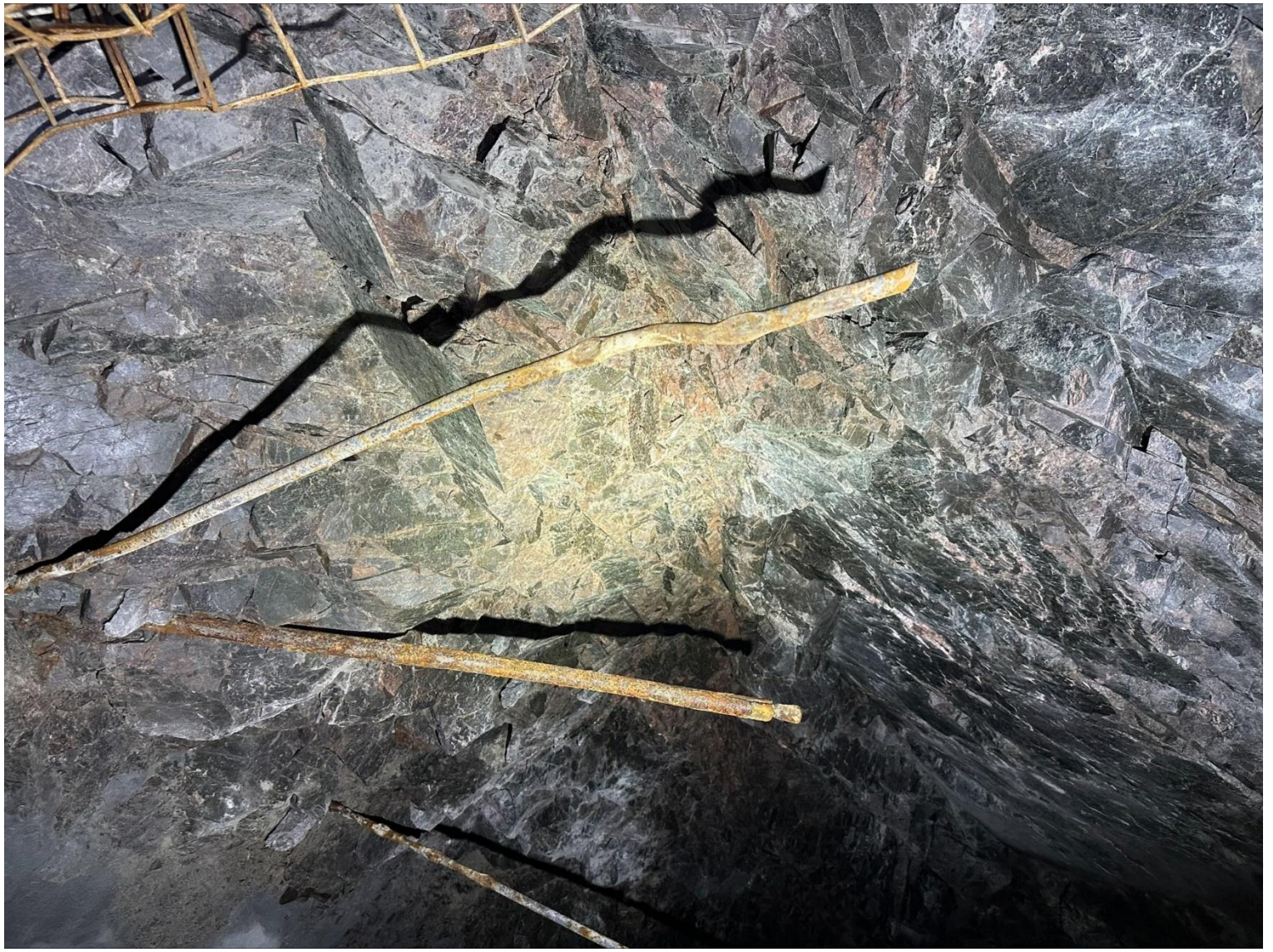
- Mechanical theory estimates 60% of the rockbolt ultimate tensile load (UTL) in shear.
- Shear loading of a rockbolt has been estimated at 70% of UTL in literature.
- Reality is significantly more complex.





In-situ shear loading of rockbolts





Laboratory shear loading methods

Single Shear Test

- Typically conducted large concrete blocks.
- Holes positioned to control boundary conditions.
- Blocks displacement rate controlled to affect desired loading angle.

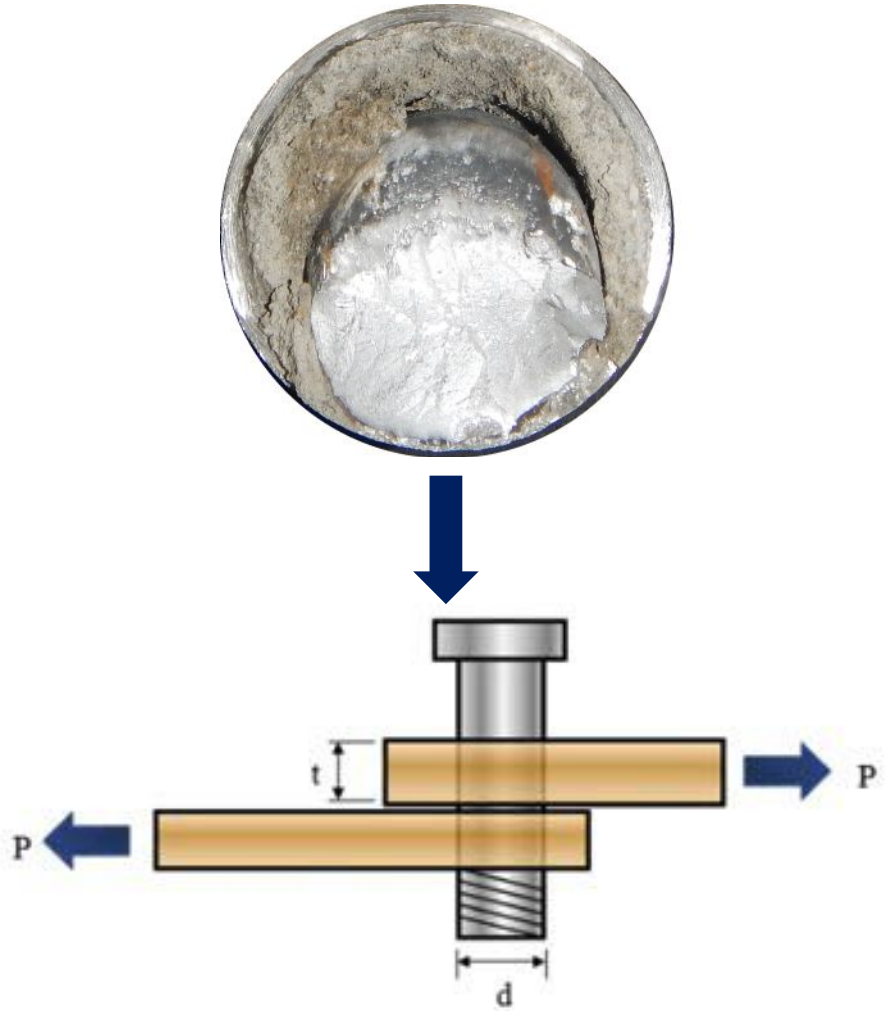
- **Selected as the method for this study**

Double Shear Test

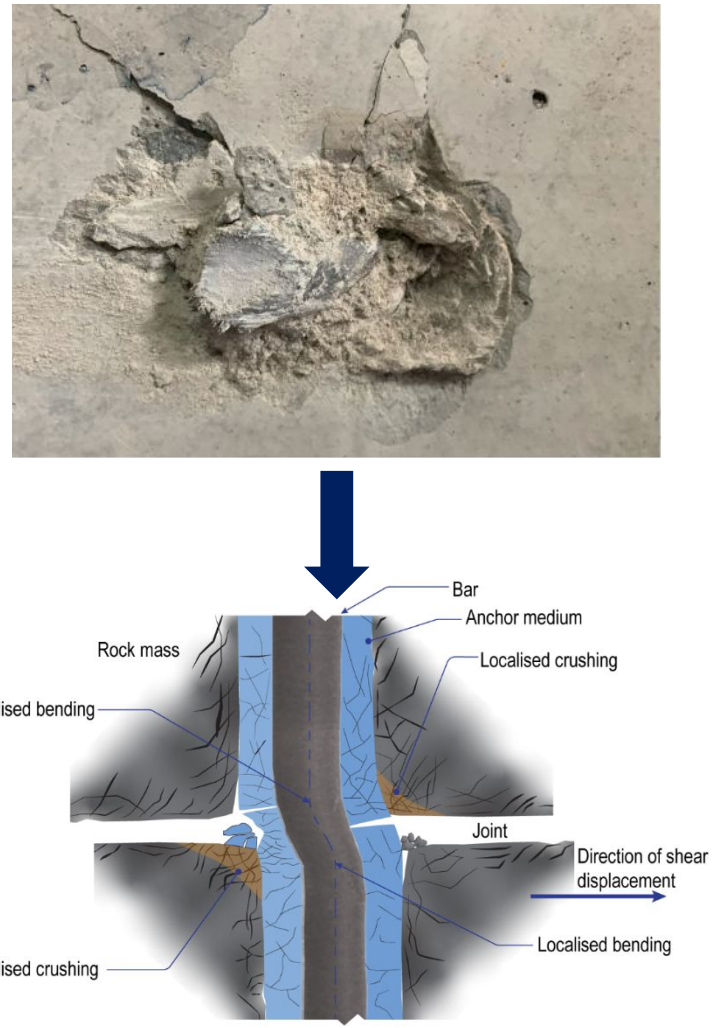
- Typically conducted in cast concrete cylinders or steel tubes.
- Boundary conditions need to be controlled to prevent failure of the concrete cylinders.
- Rockbolts inclined to adjust loading angle.
- Applied load halved to determine shear load

Boundary conditions

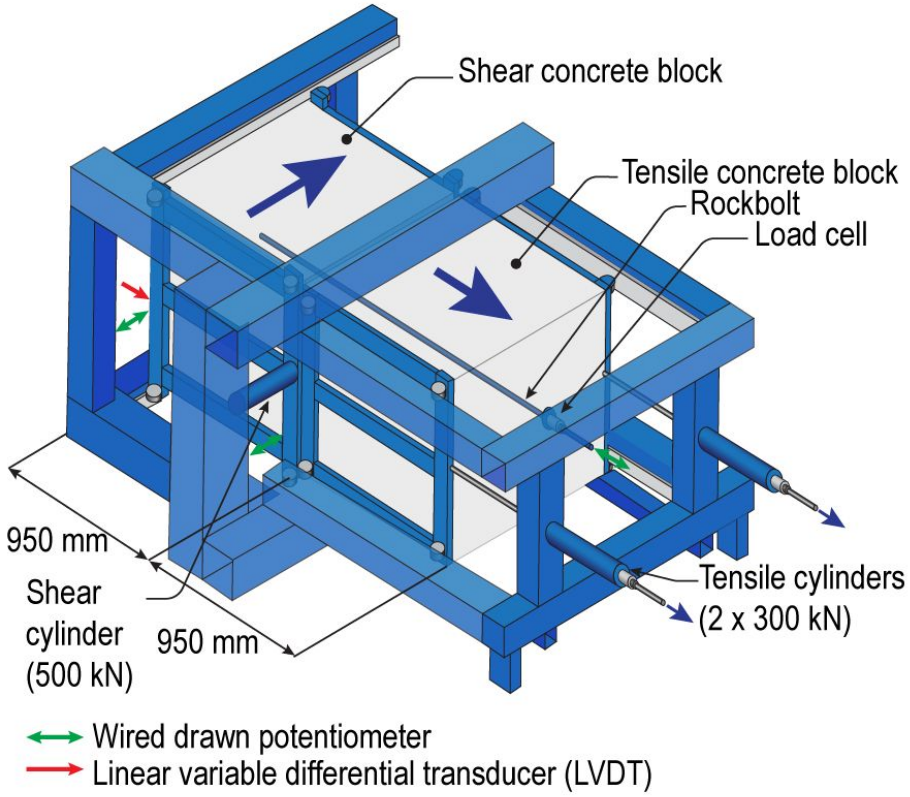
Steel host tubes



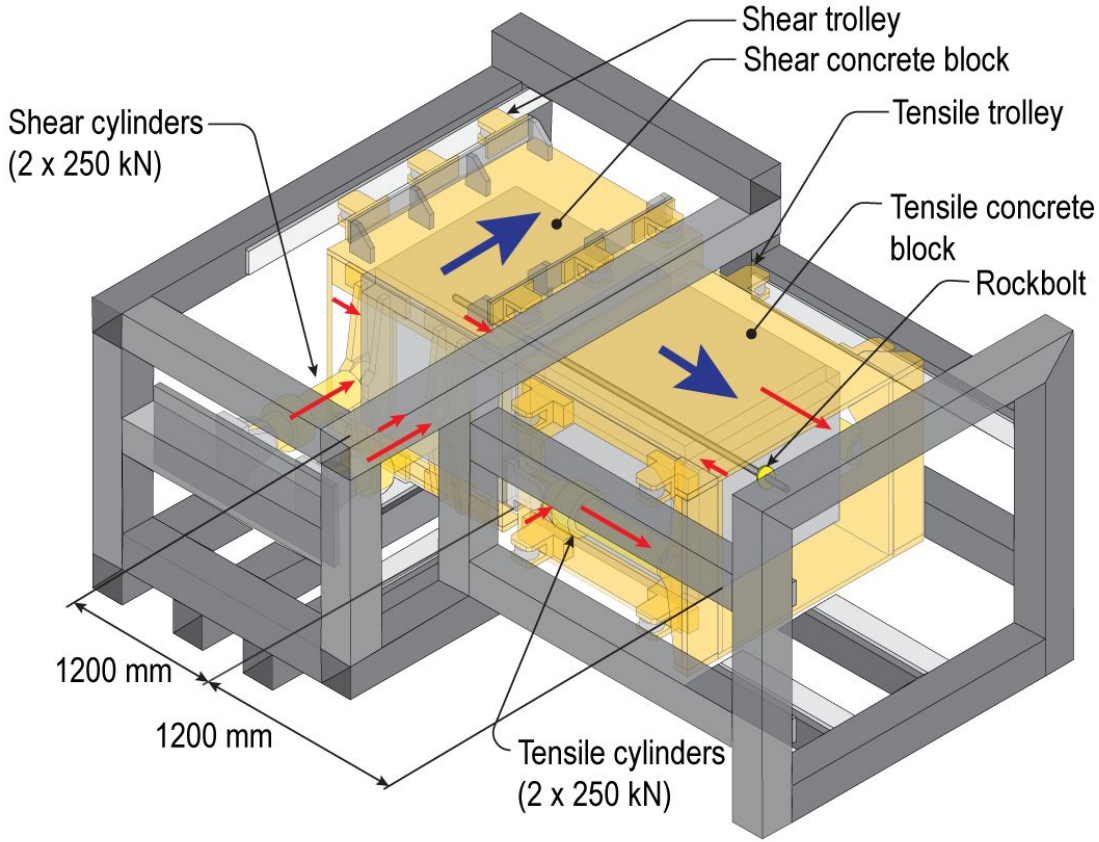
Concrete blocks



Shear loading apparatus in concrete blocks



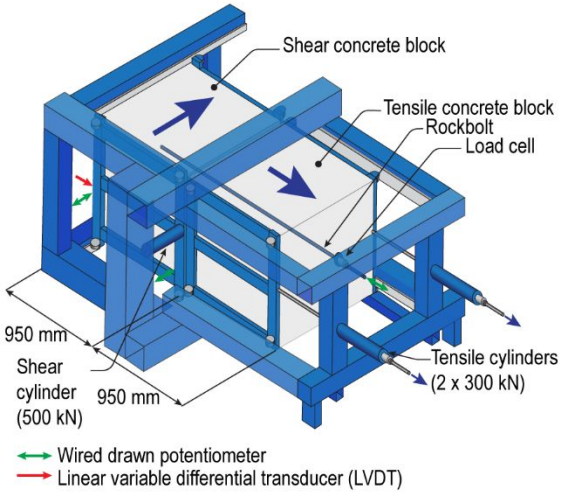
SINTEF - Norway

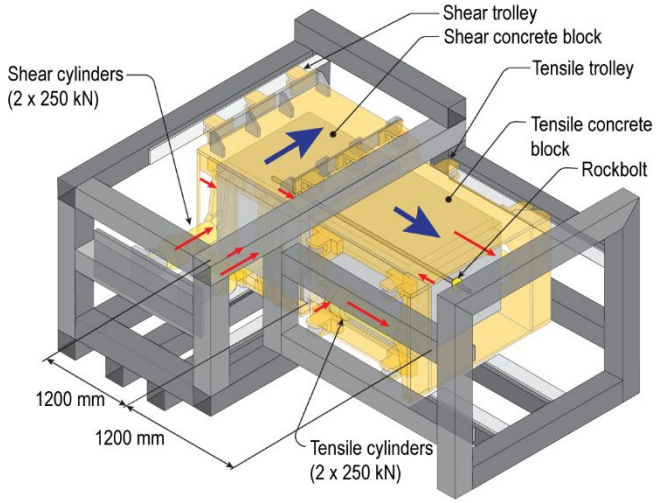


Epiroc CST – South Africa

Shear loading apparatus

Both systems are similar in construction and operation.



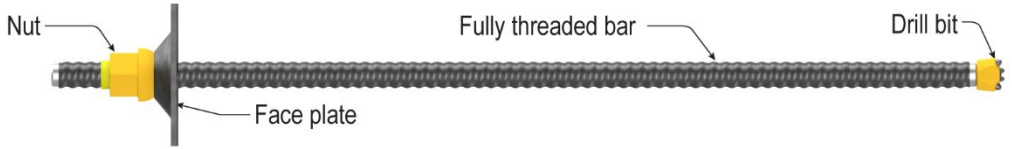


	SINTEF	CST
Max. shear displacement	150 mm	300 mm
Max. shear load	500 kN	500 kN
Max. tensile displacement	250 mm	500 mm
Max. tensile load	600 kN	500 kN
Block size	950 x 950 x 950 mm	1200 x 1200 x 1000 mm
Max. bolt length	1.8 m	2.4 m

Data collection

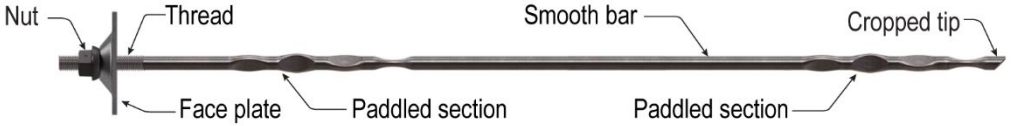
Conventional Rockbolts
(normal ground conditions)

Rebar Rockbolt



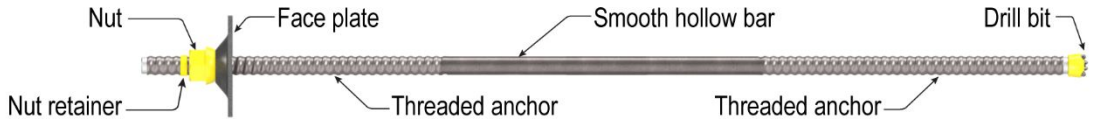
Self-Drilling Anchor

Energy-absorbing Rockbolts
(high-strain ground conditions)



Paddled Energy-absorbing Rockbolt

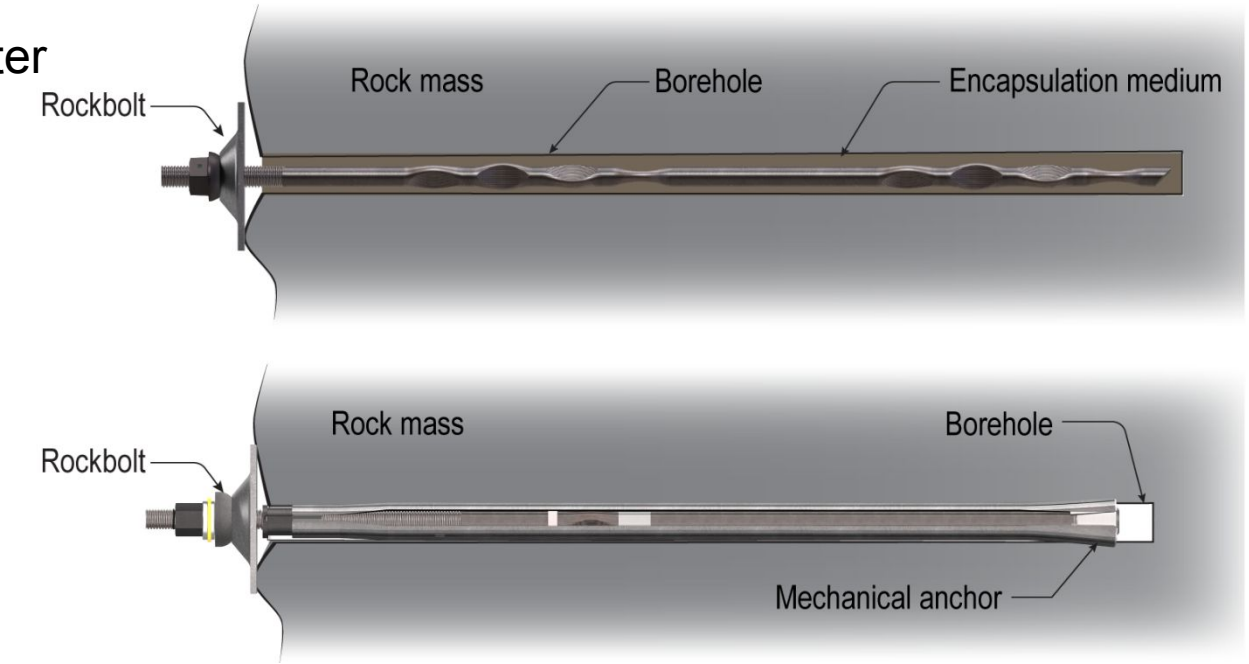
Yielding Mechanical Hybrid Rockbolt



Energy-absorbing Self-drilling Rockbolt

Data sourcing

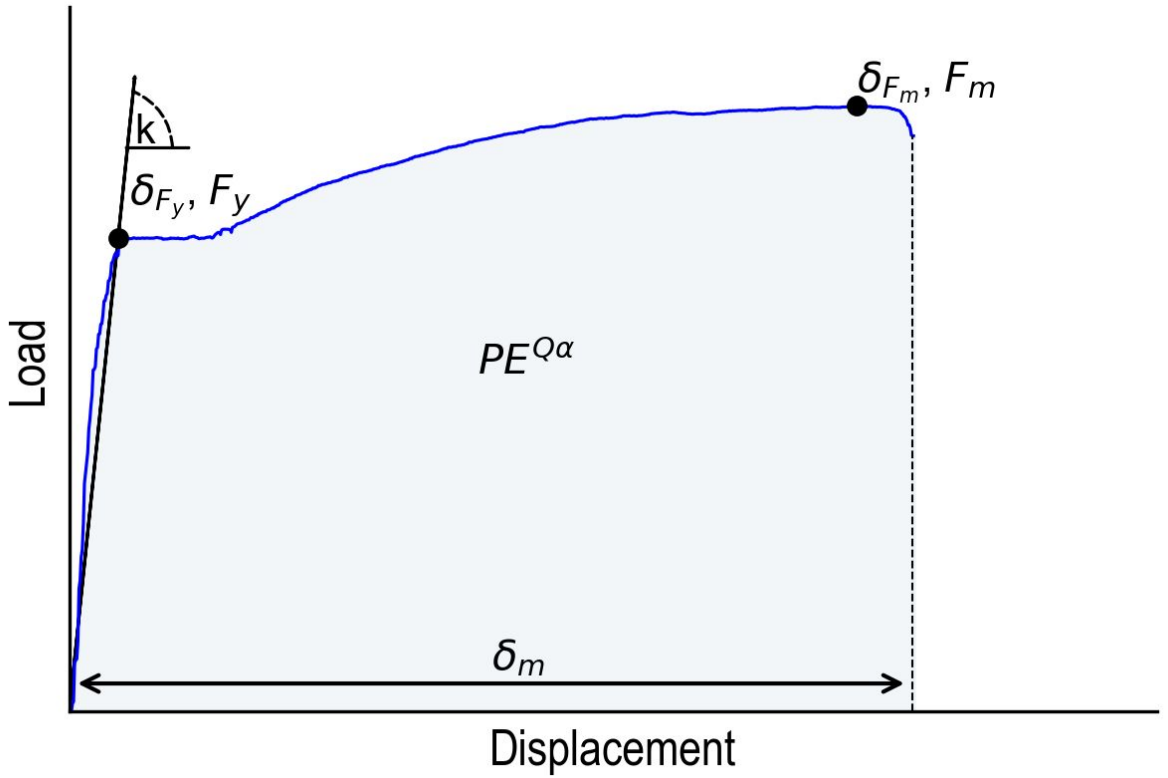
- Two machines:
  - SINTEF Rockbolt Pull tester
  - Epiroc Combination Shear and Tensile Tester
- Rockbolts
  - Conventional
  - Energy-absorbing rockbolts
  - Solid bar
  - Hollow bar
- Two anchoring methods
  - Mechanical anchor
  - Fully encapsulated - grout



Comparison parameters

Load displacement response

- F_m: Ultimate load (kN)
  Peak load recorded during the loading cycle
- δ_{F_m}: Displacement at ultimate load (mm)
  Displacement at the time at which the peak load is recorded
- $PE^{Q\alpha}$: Plastic energy dissipated
  Plastic energy dissipated at rupture, calculated as the integral of the load and displacement response.



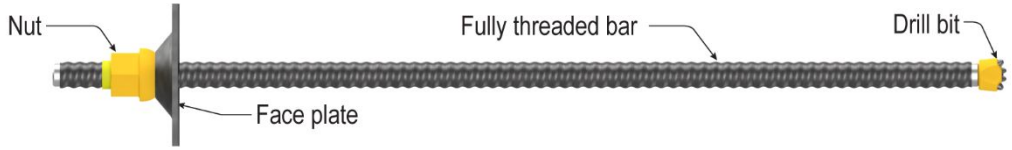
Conventional rockbolts

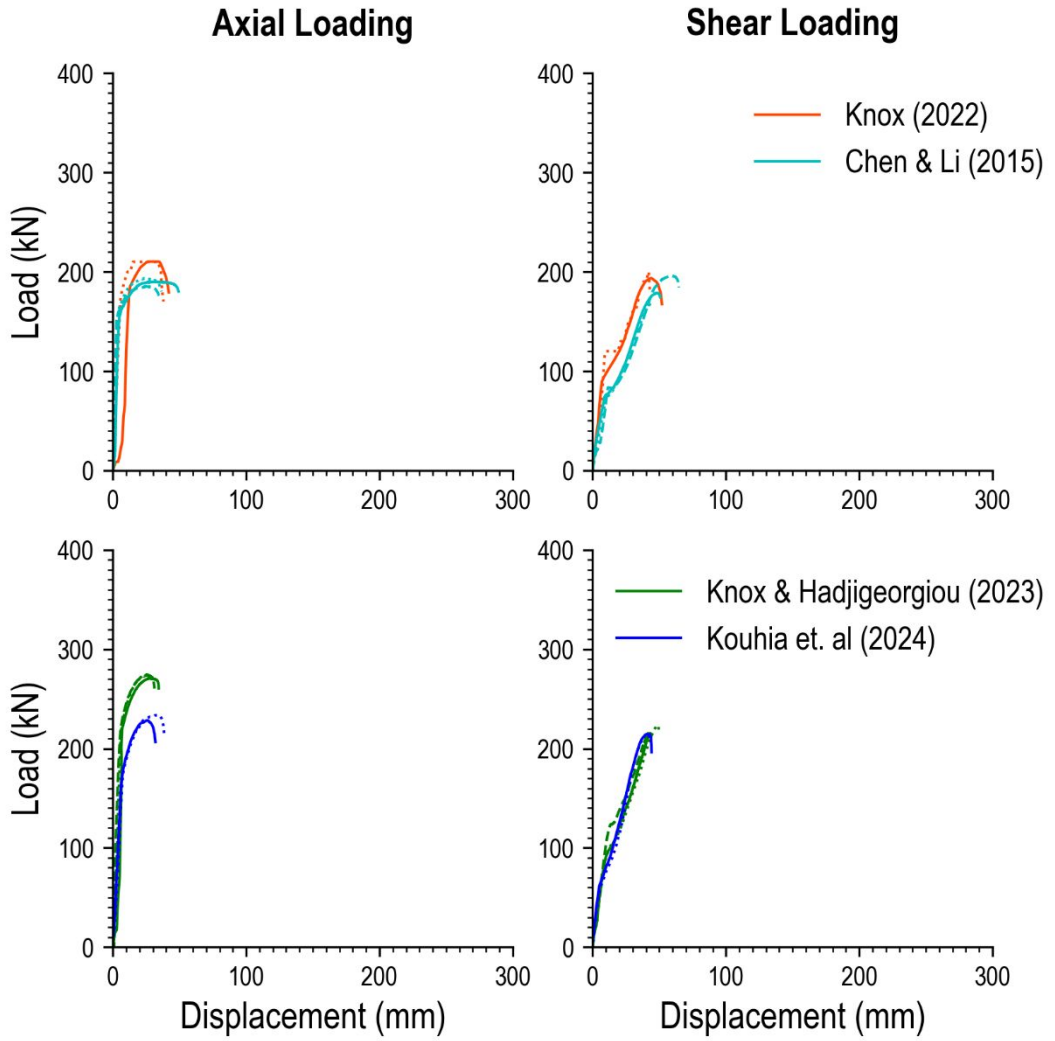
Ø20 mm Rebar Rockbolt

- 2 x data sources – one per machine.
- Both sets of rockbolts sourced in the Nordics.

Self-Drilling Rockbolt

- 1 x R28 – CST
- 1 x R25 - SINTEF

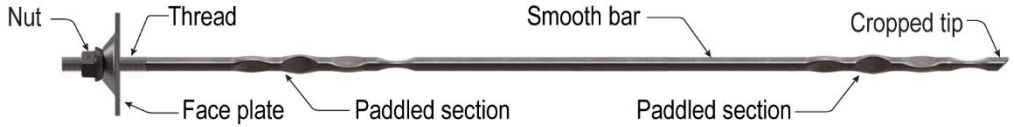




Energy-absorbing rockbolts - Encapsulated

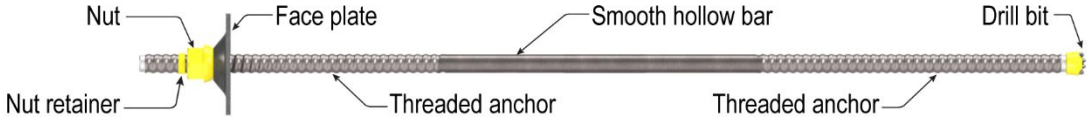
Ø20 mm Paddled Energy-absorbing

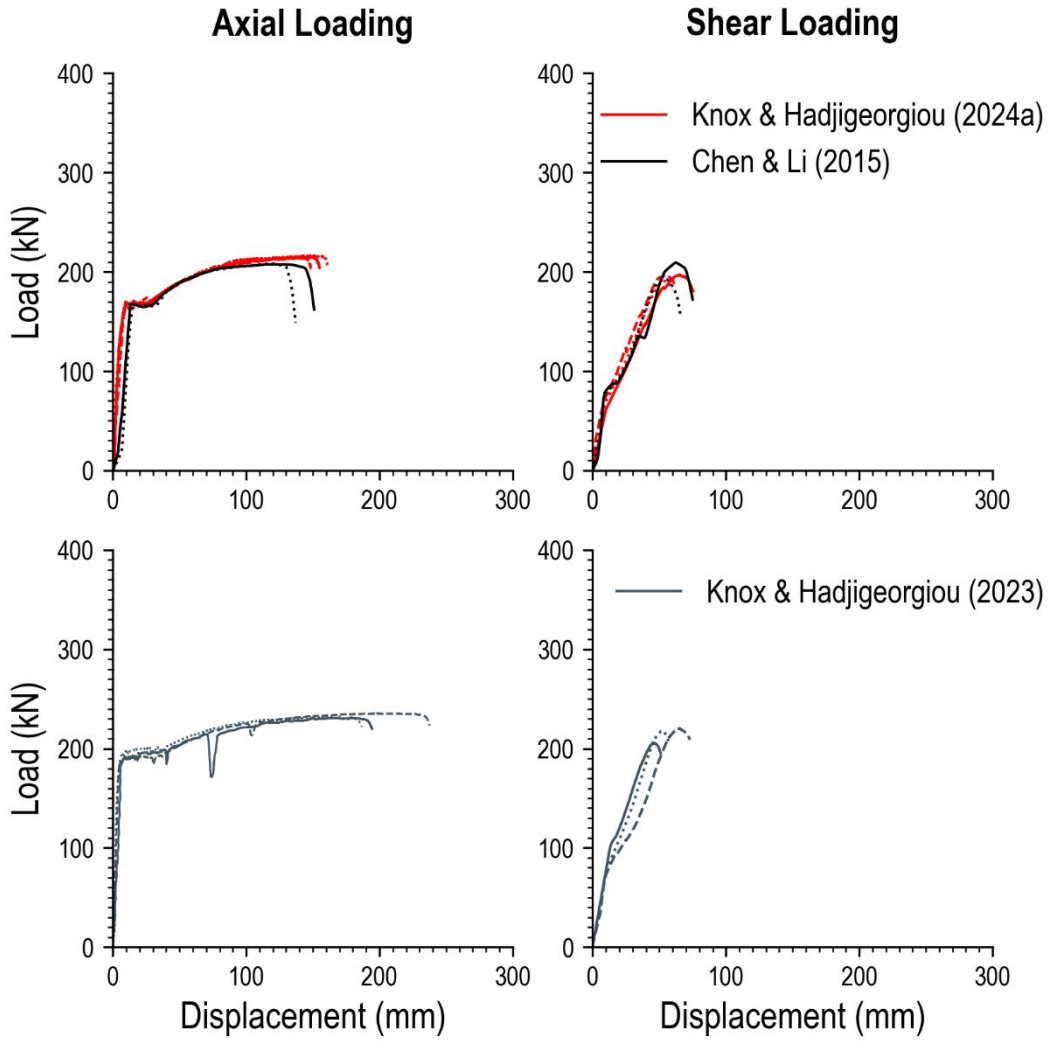
- 2 x data sources – one per machine.
- SINTEF – Ø20 mm x 2.0 m D-Bolt



Energy-absorbing Self-Drilling Rockbolt

- 1 x R28 – CST

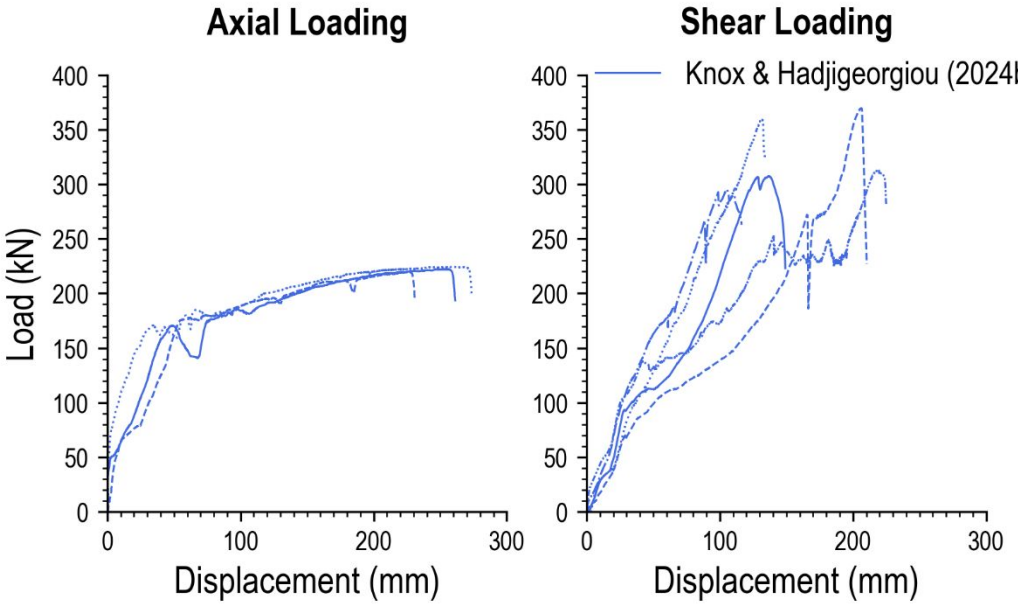


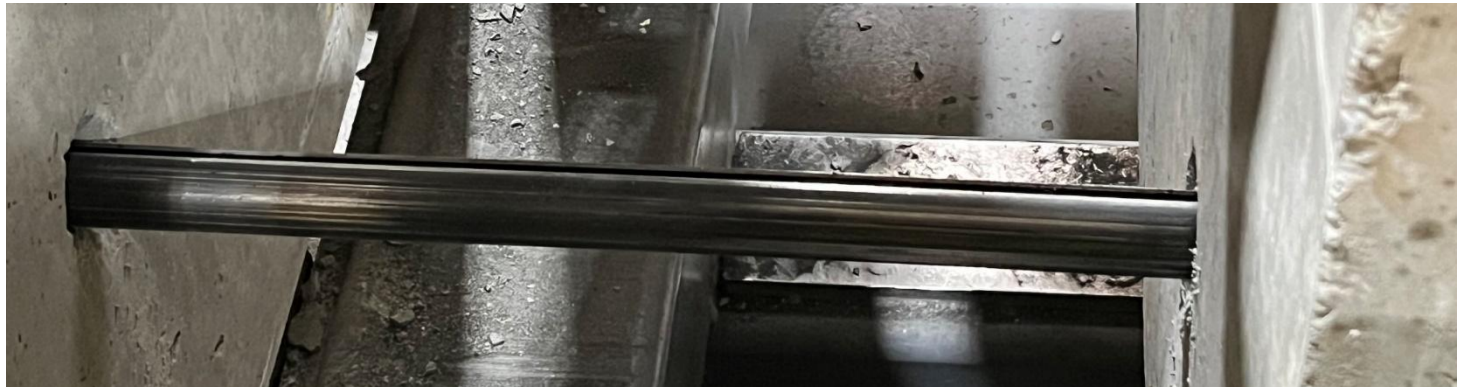


Energy-absorbing rockbolts

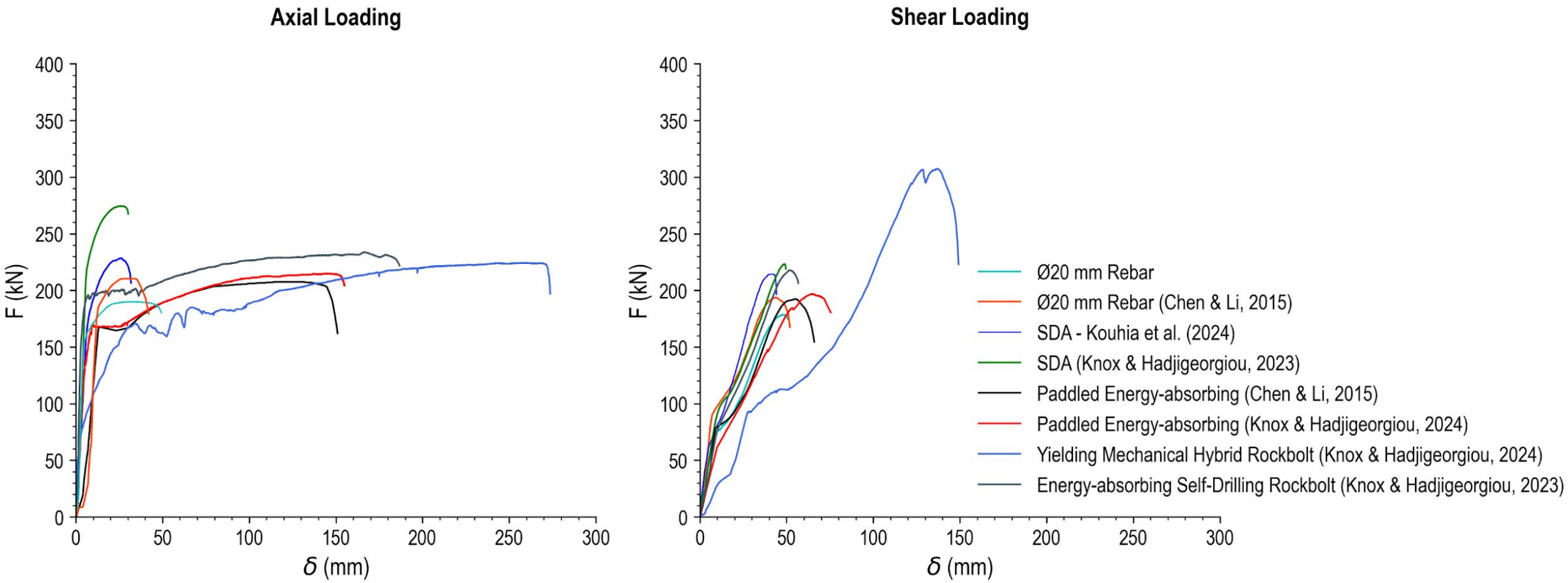
Yielding Mechanical Hybrid Rockbolt

- 1 x data source
- Ø20 mm bar, Ø39 mm Friction unit, 2.4 m

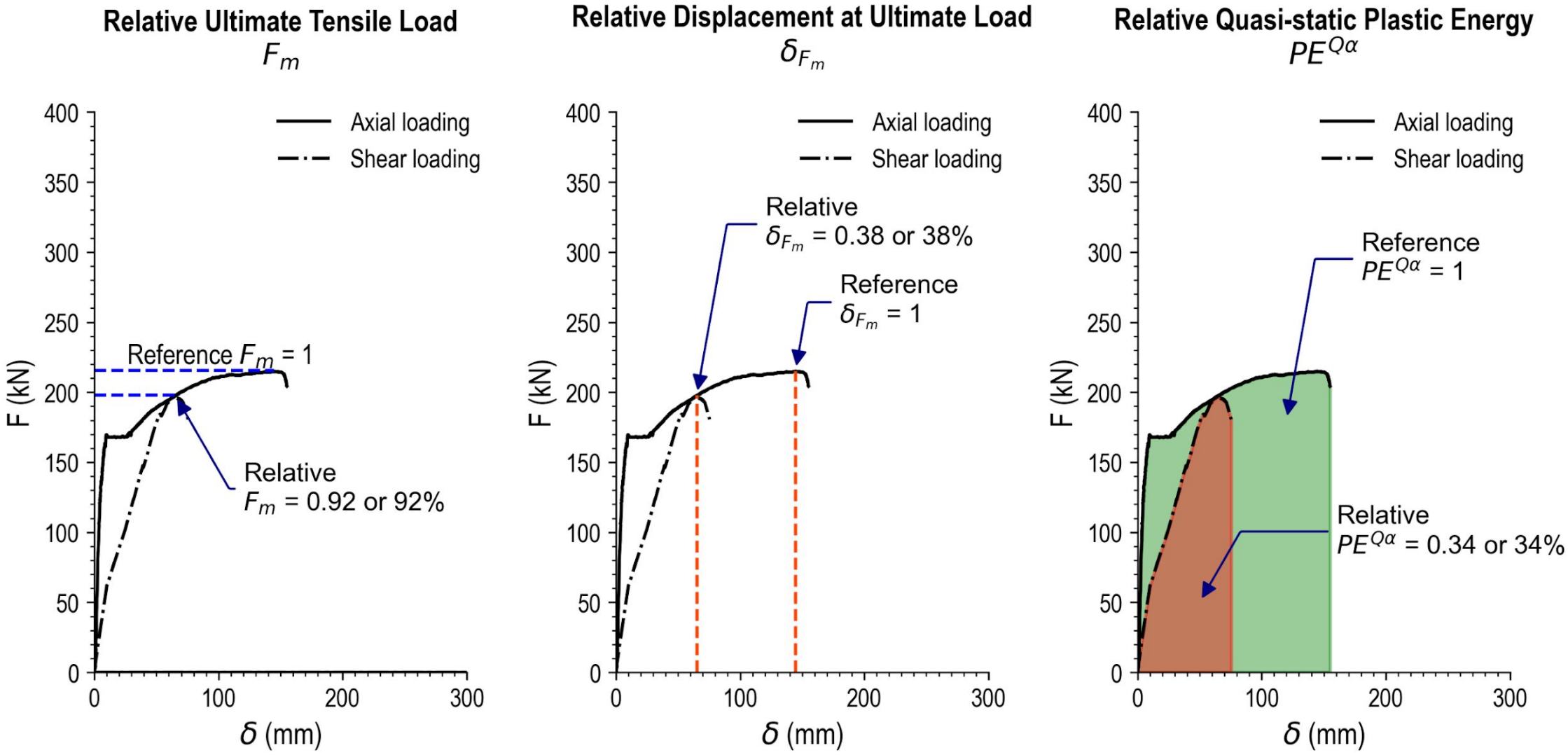




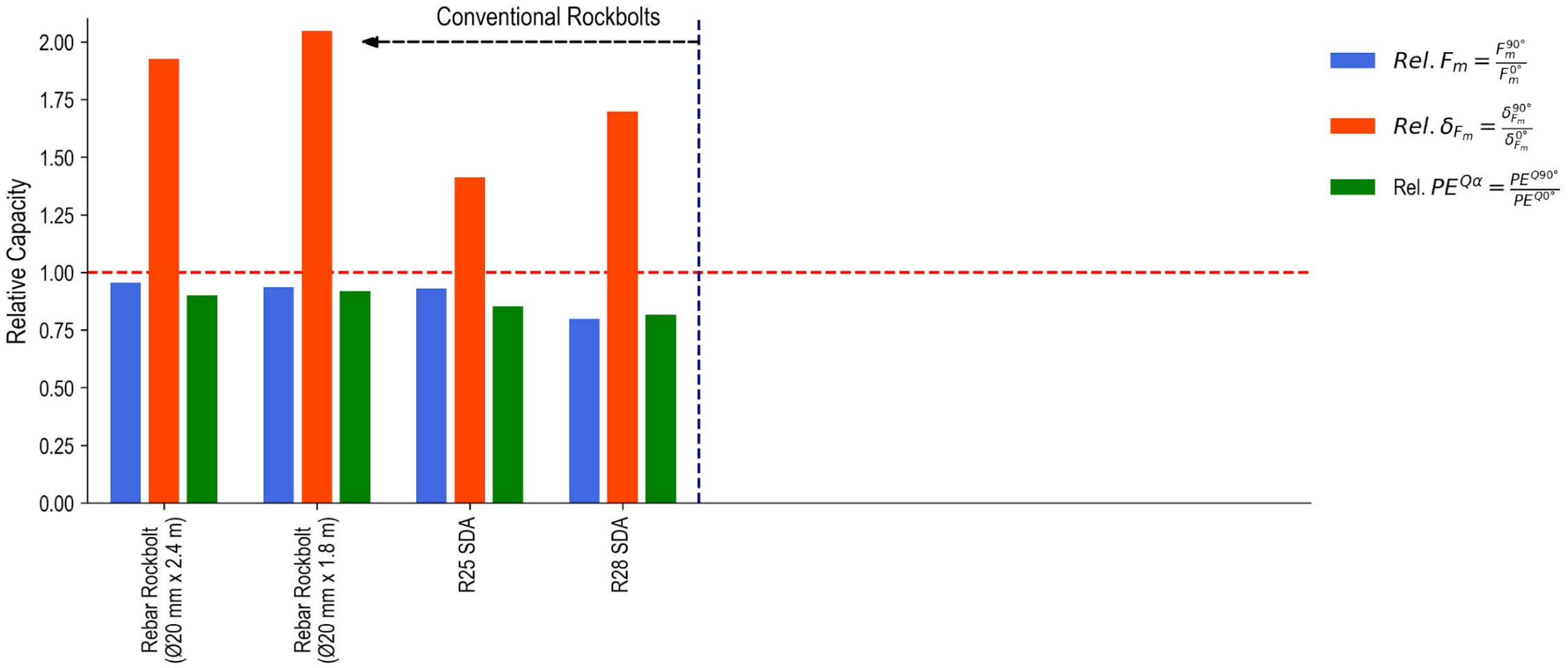
Compilation of results



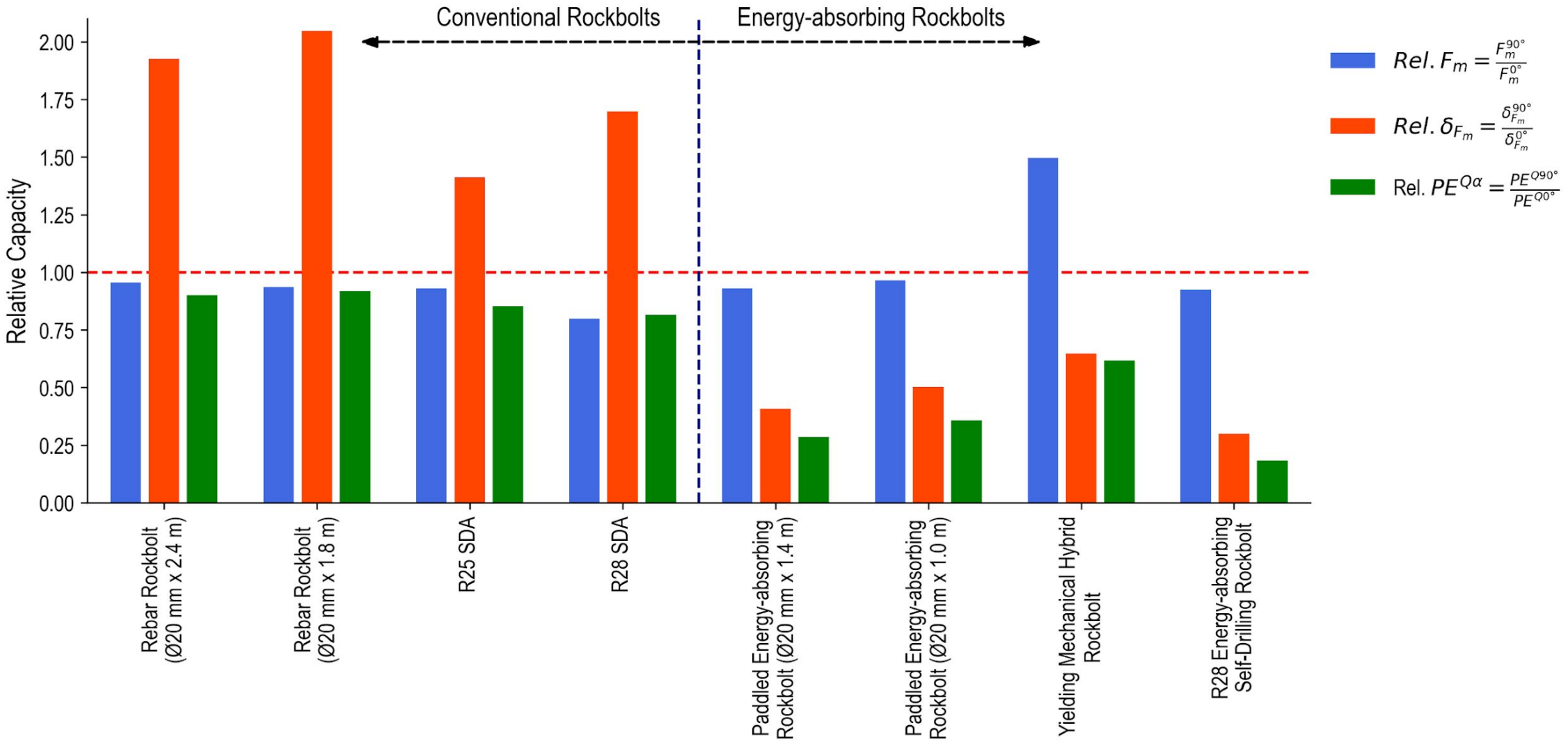
Relative capacity



Relative capacity



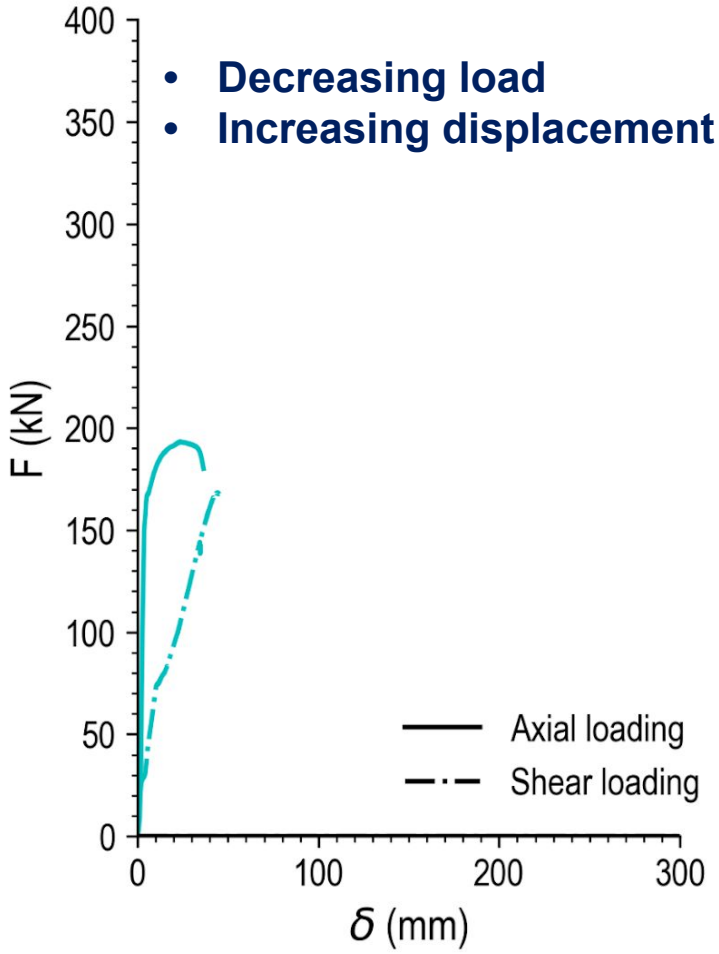
Relative capacity



Three distinct behaviours

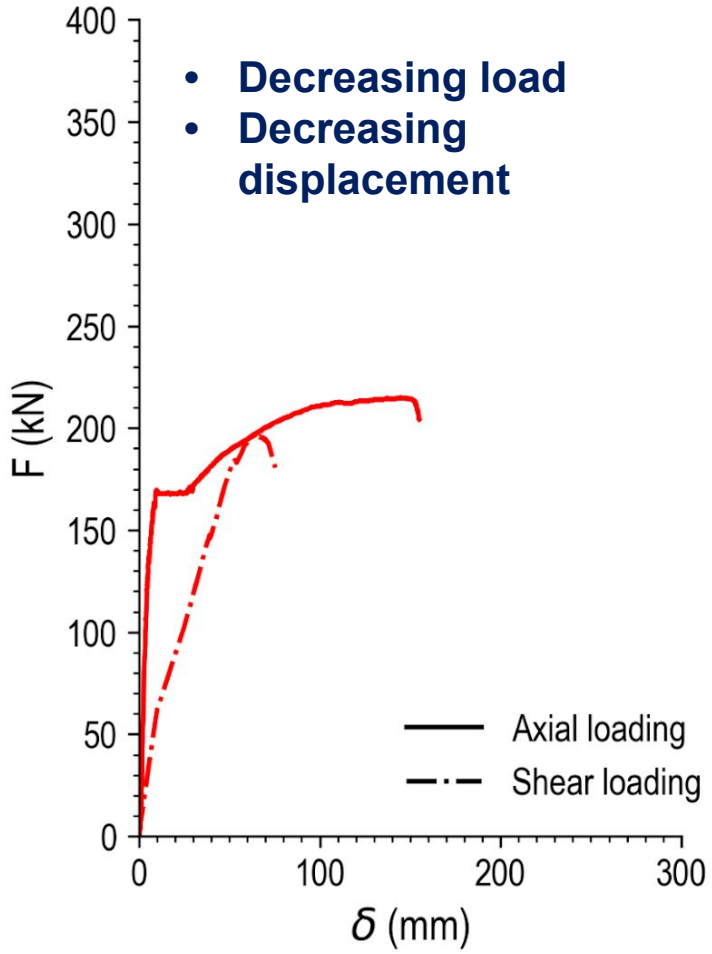
Fully Encapsulated Conventional

- Decreasing load
- Increasing displacement



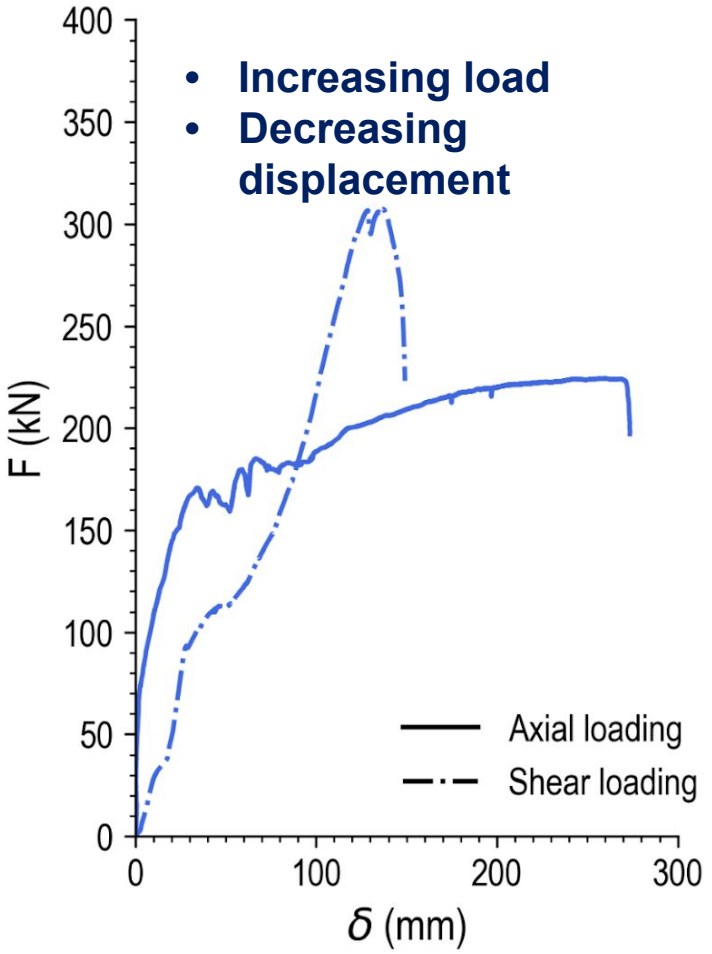
Fully Encapsulated Energy-absorbing

- Decreasing load
- Decreasing displacement



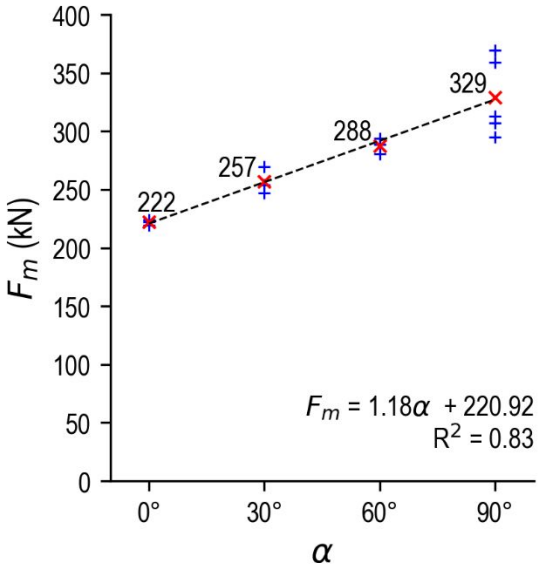
Yielding Mechanical Hybrid Rockbolt

- Increasing load
- Decreasing displacement

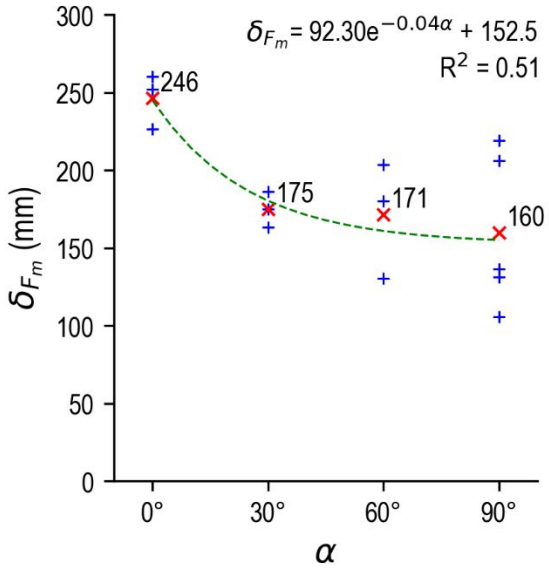


Conclusions

- Based on the work presented we have a better understand of the behaviour of rockbolts in shear.
- When considering behaviour in shear
  - Influence on load capacity
  - Influence on displacement capacity
  - Energy capacity in shear decreases relative to the axial loading case
- There are different criteria that can be used to compare different bolts
  - Ultimate load capacity
  - Displacement capacity at rupture
  - Resilience (ratio tensile / shear capacity)
- Practical Considerations
  - Transition – where does it occur?
  - Design value?



Ultimate load



Displacement at ultimate load