



NTNU

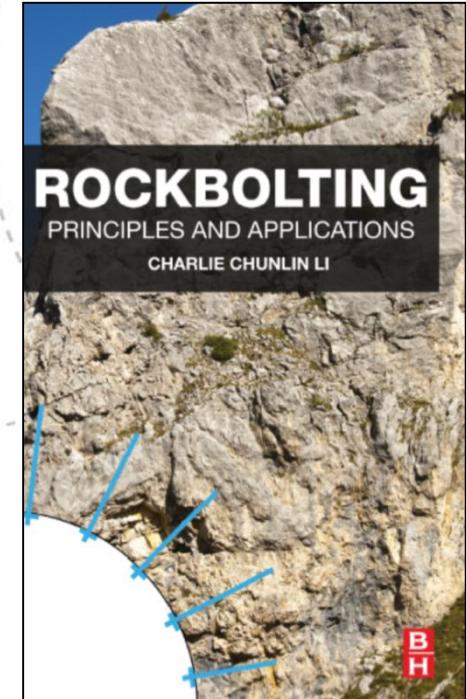
Innovation and Creativity

Fjellbolting Prinsipper og Applikasjoner

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NTNU

NBGs boltkurs 25.-26. september 2017, Trondheim



Innehold

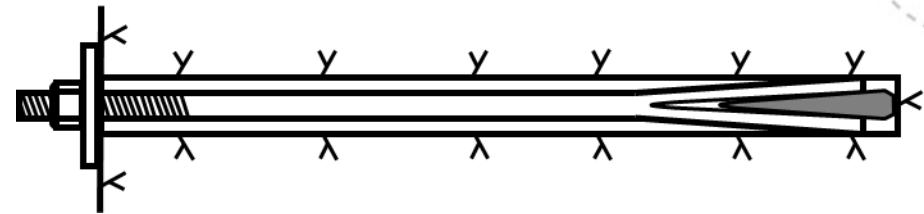
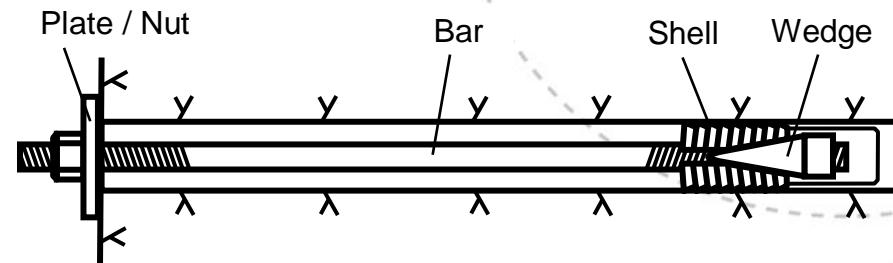
- Kap 1: Innledning
- Kap 2: Typiske bolter
- Kap 3: **Utførelse av bolter**
- Kap 4: **Mekanikk av bolting**
- Kap 5: **Boltingsplanlegging**
- Kap 6: Boltinstallasjon
- Kap 7: Kvalitetskontroll
- Kap 8: Numerisk modellering
- Kap 9: **Eksempler av fjellbolting**

Kap 2: Typiske bolter

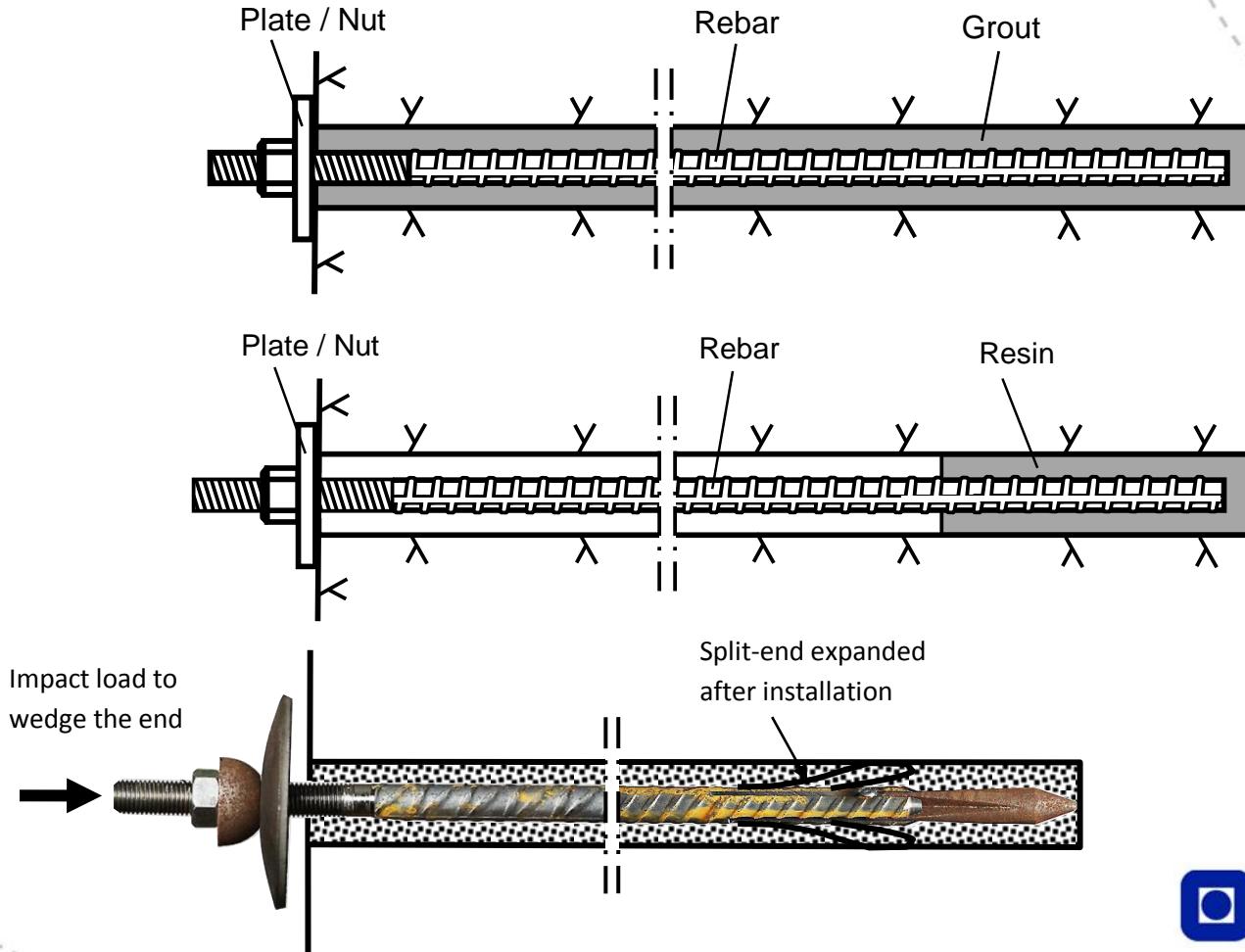
- Bolttyper
- Hvordan bolten fungerer
- Spesifikasjoner: typiske diameter, flytende og bruddgrenser, tøyningsgrenser

Mekanisk bolt

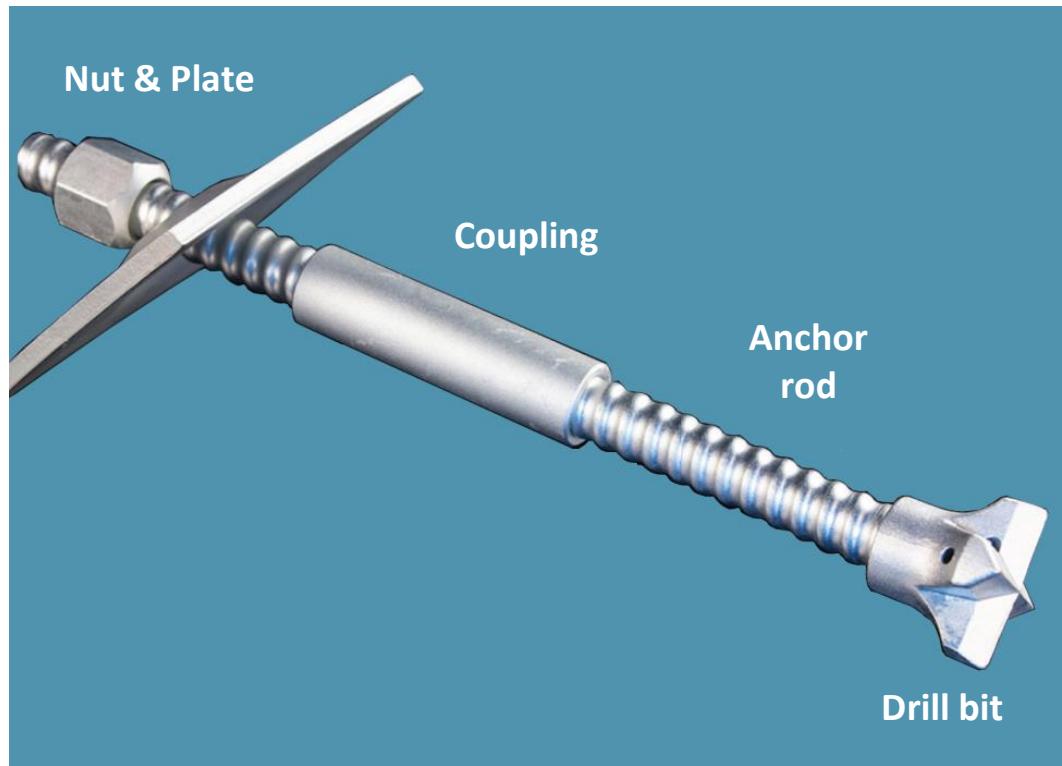
- Ekspansjonsbolt
- " Slot-and-wedge" bolt



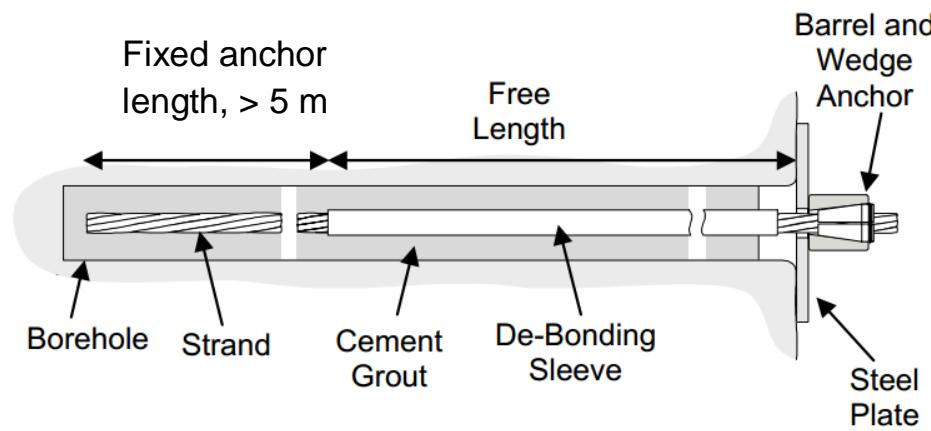
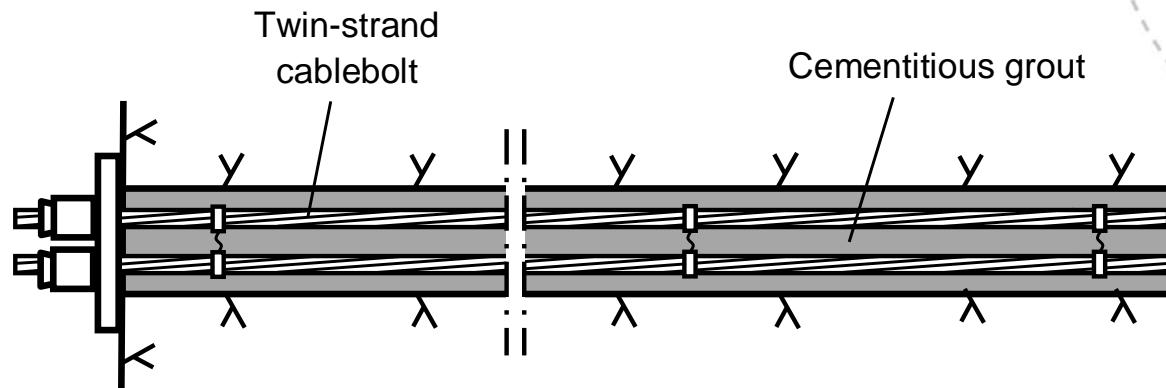
Limit bolt



Self-drilling bolt



Kabelbolt

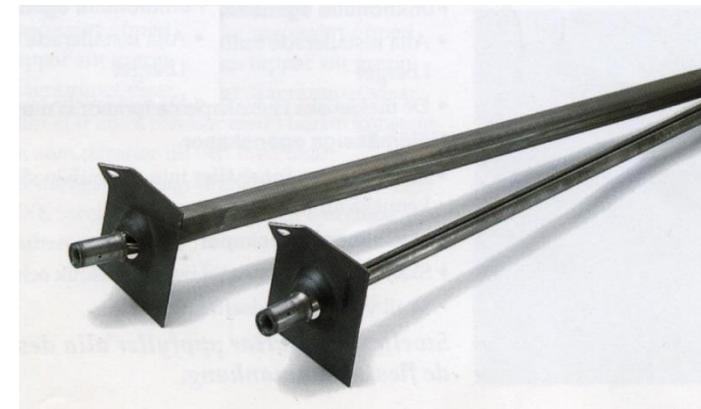
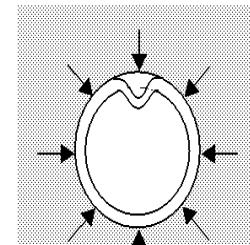
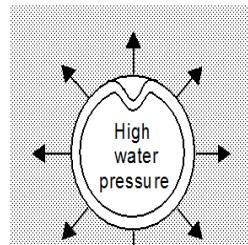
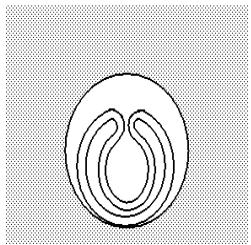


Friksjonsbolter

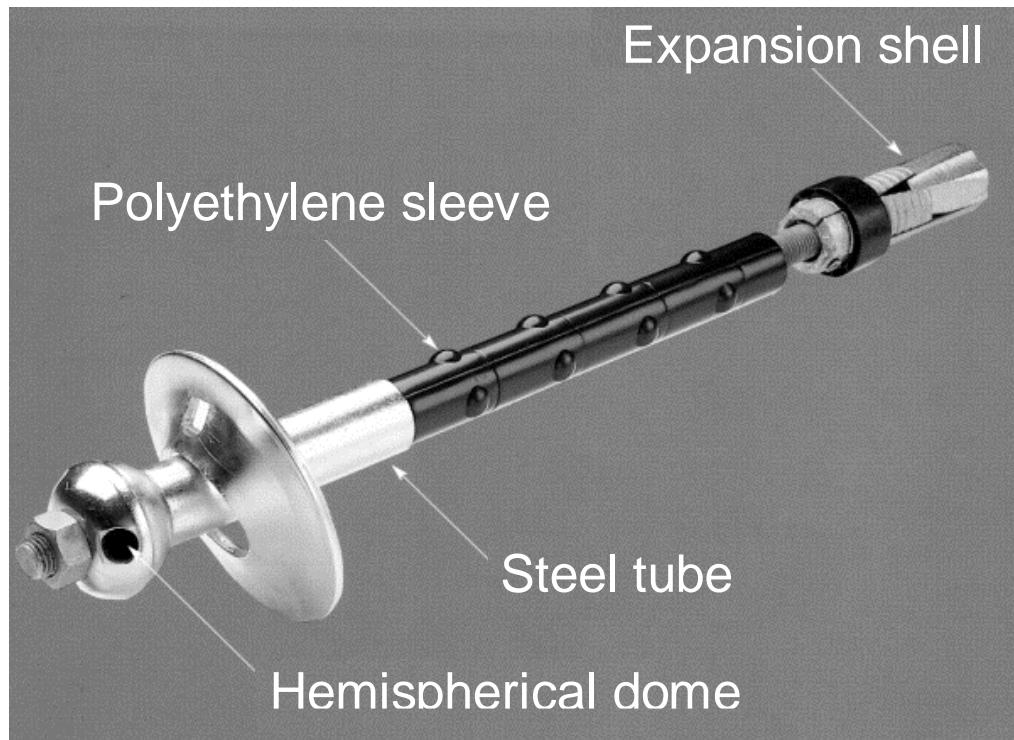
- Split set



- Ekspansjonsbolt

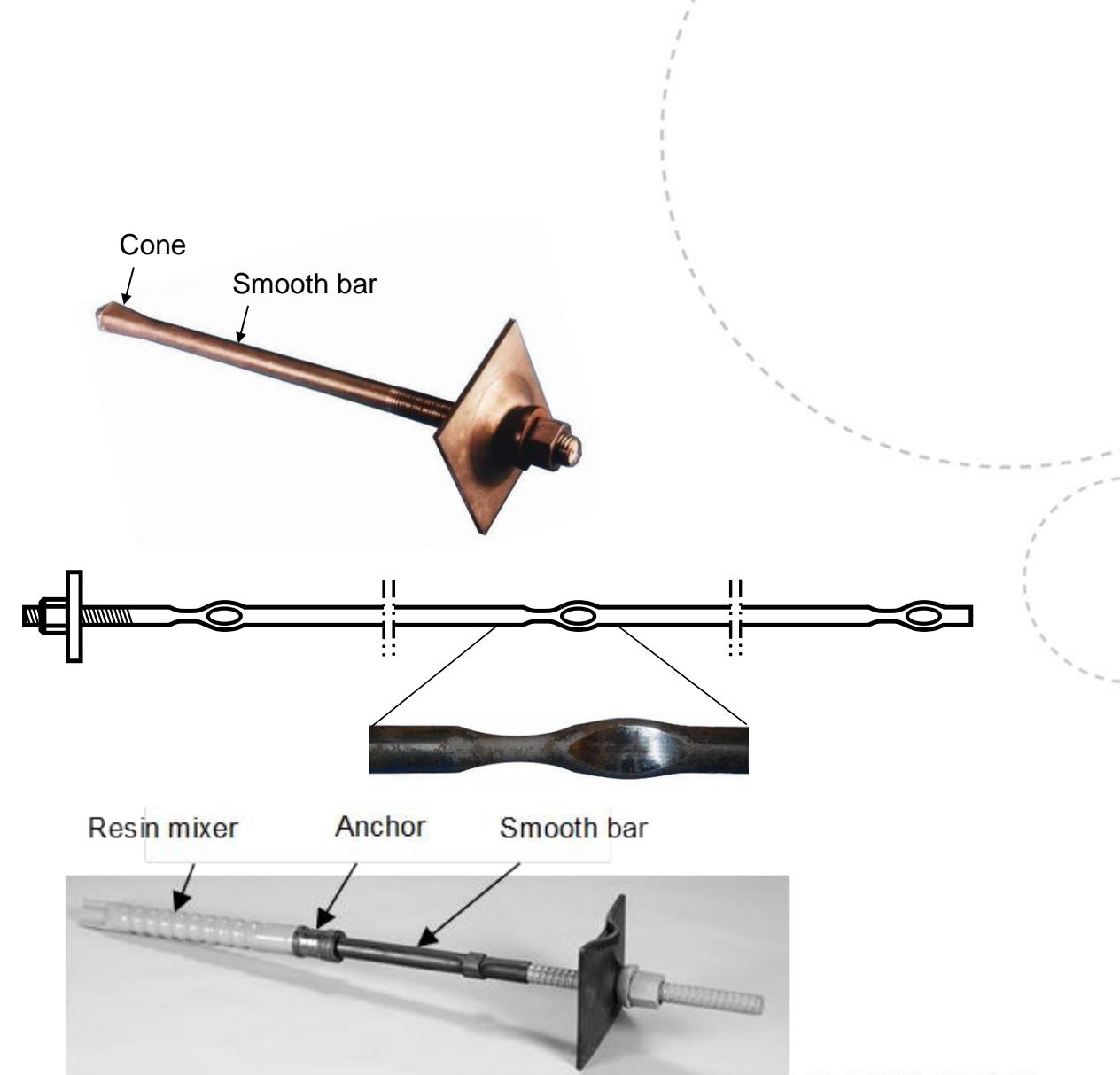


Hybridbolt



Energibolter

- Cone bolt
- D-bolt
- Garford bolt

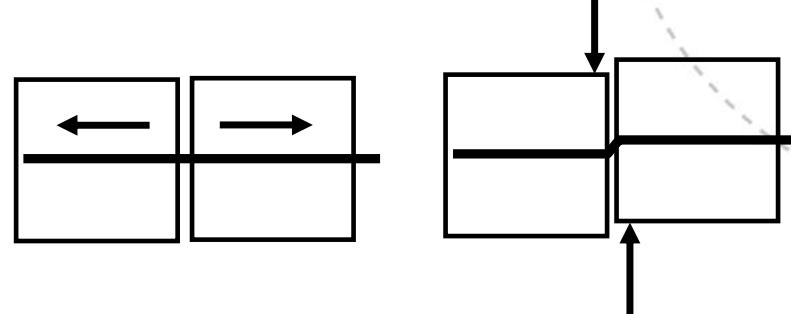


Kap 3: Utførelse av bolter

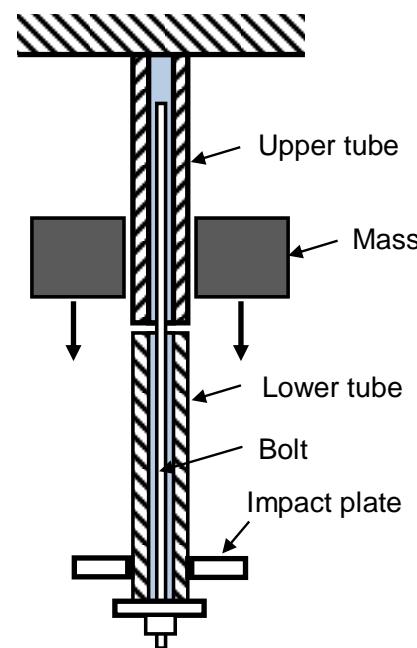
- Prøvingsmetoder: statisk og dynamisk
- Statisk utførelse
- Dynamisk utførelse
- Feltobservasjoner

Prøvingsmetoder

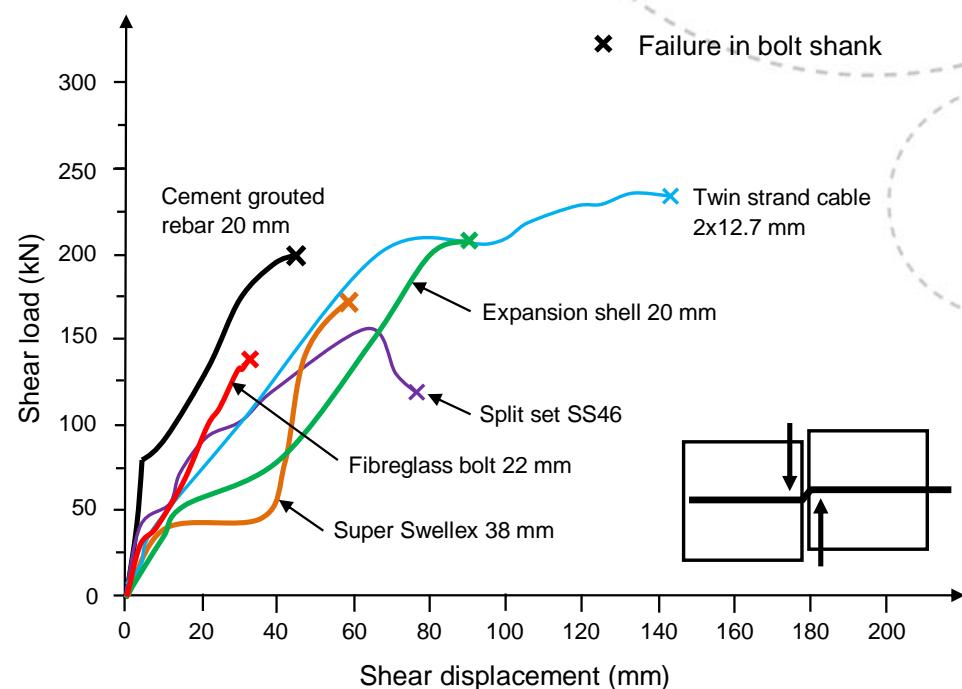
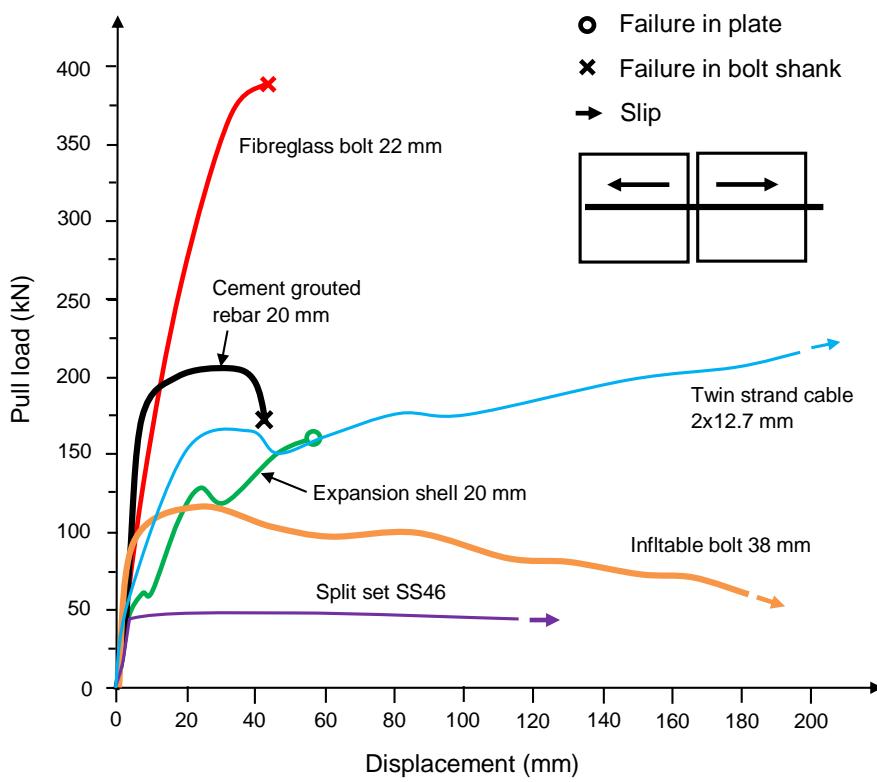
- Statisk prøving



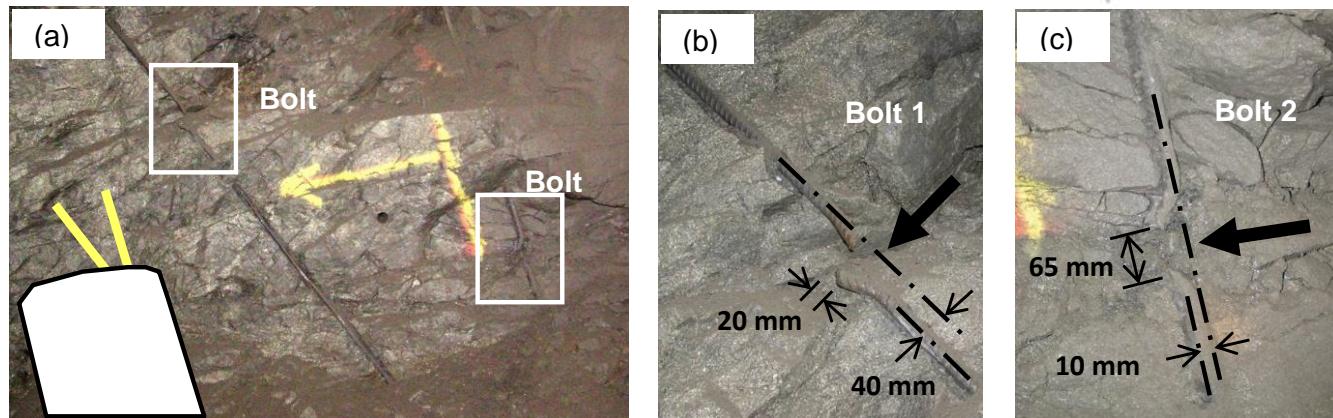
- Dynamisk prøving



Statisk utførelse



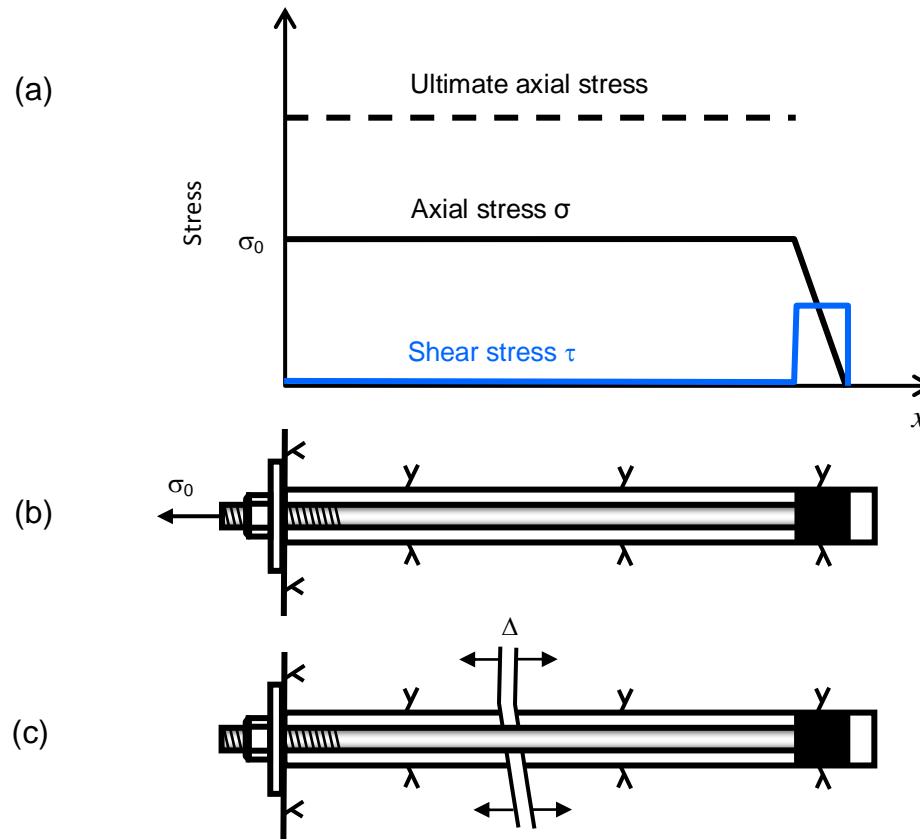
Feltobservasjoner



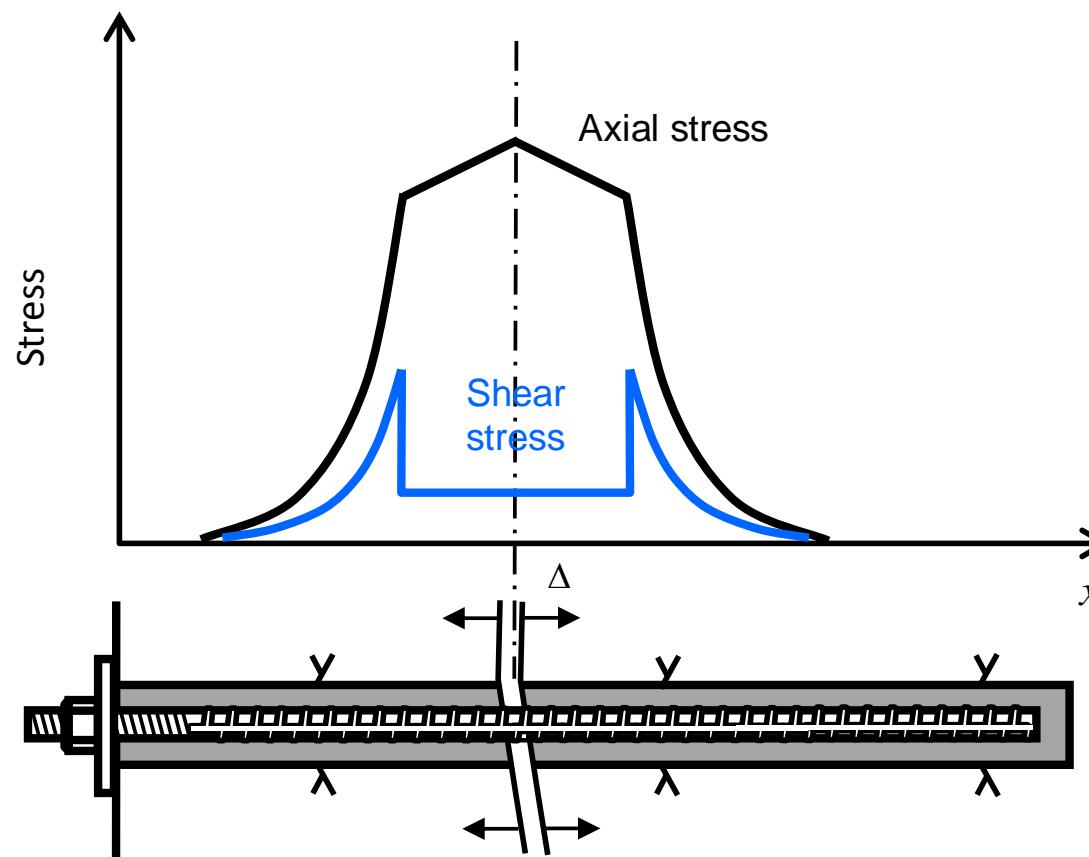
Kap 4: Mekanikk av bolting

- Boltebelastningsmodeller
- Interaksjon mellom bolter og bergmassen
- Interaksjon mellom bolter og andre sikringselementer
- Bergmasseresponsekurven og bergsikringslinjen

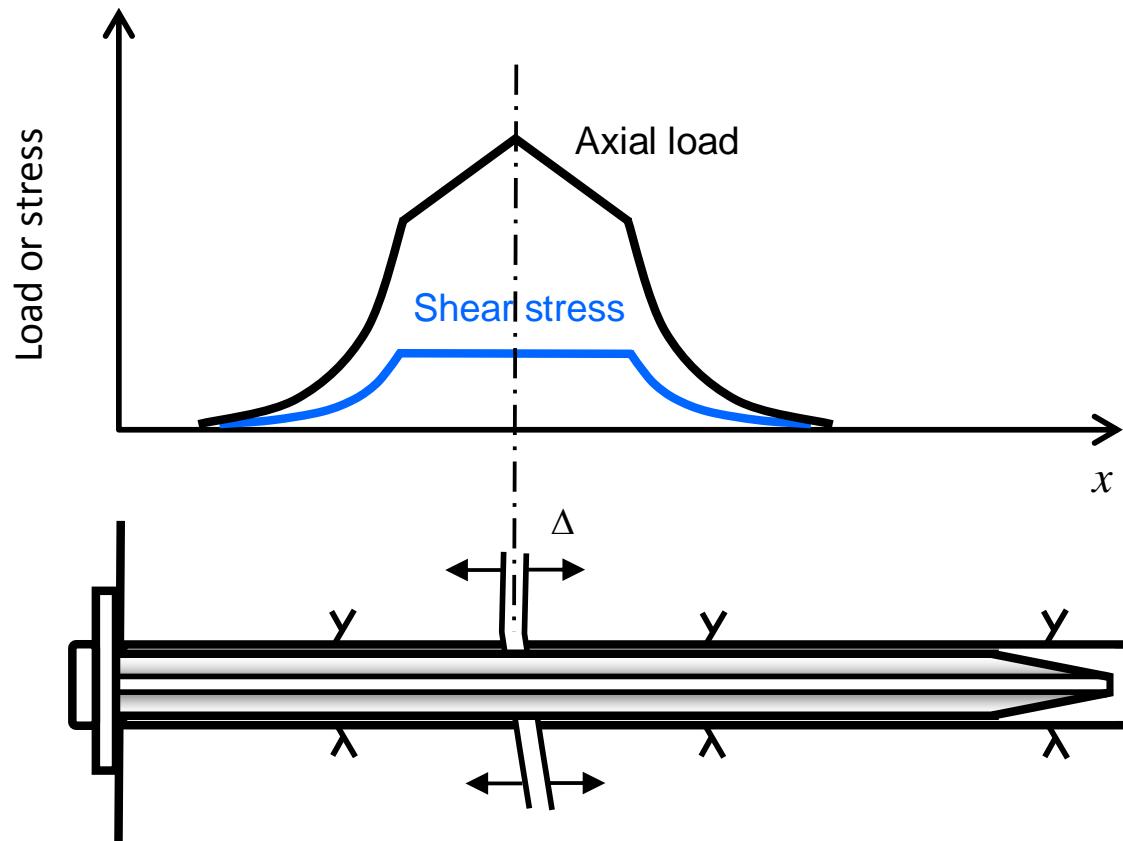
Model for mekanisk bolt



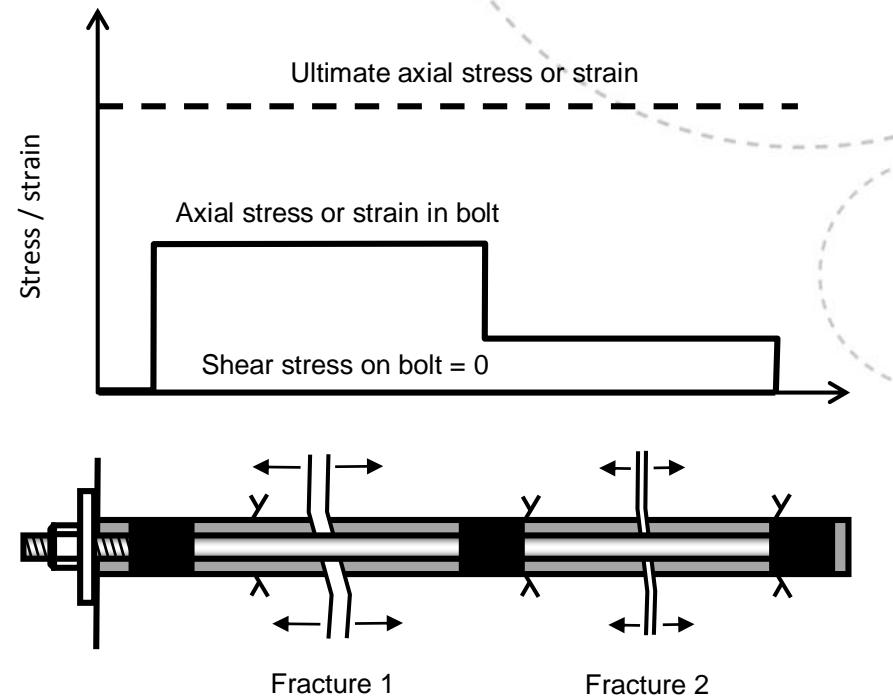
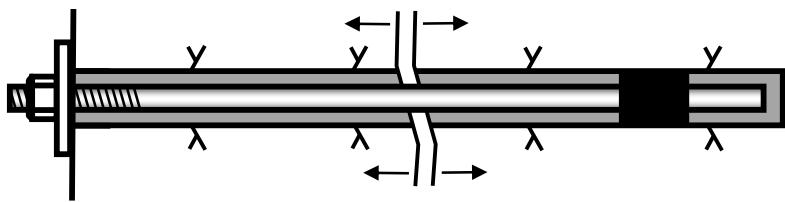
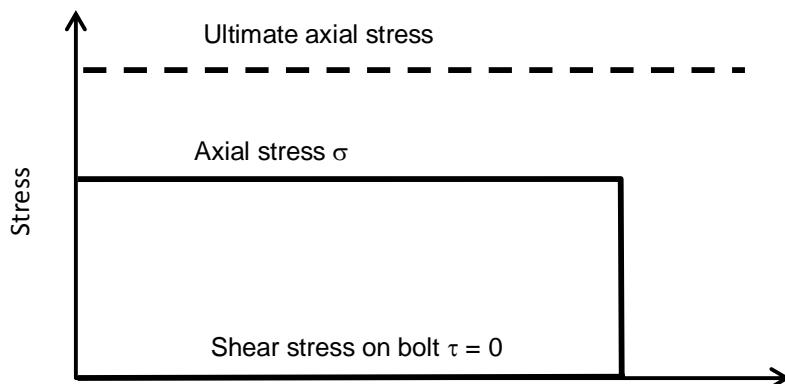
Modell for limit bolt



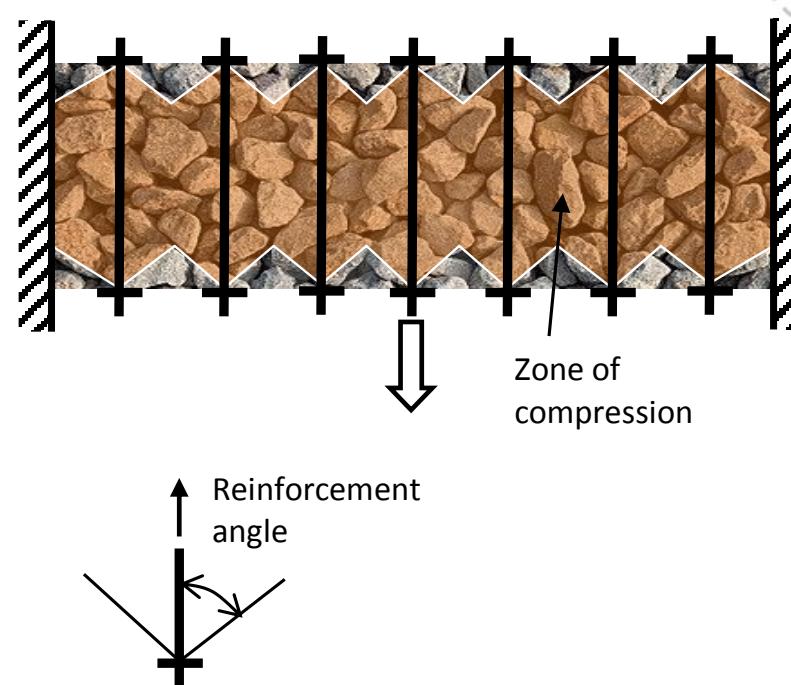
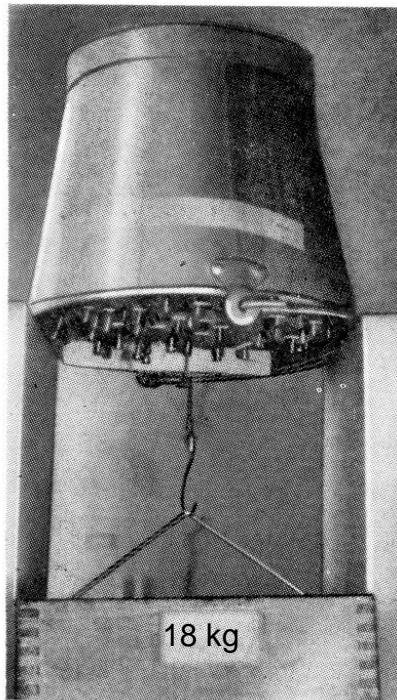
Modell for friksjonsbolter



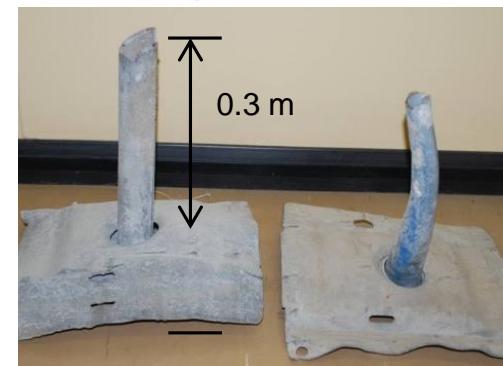
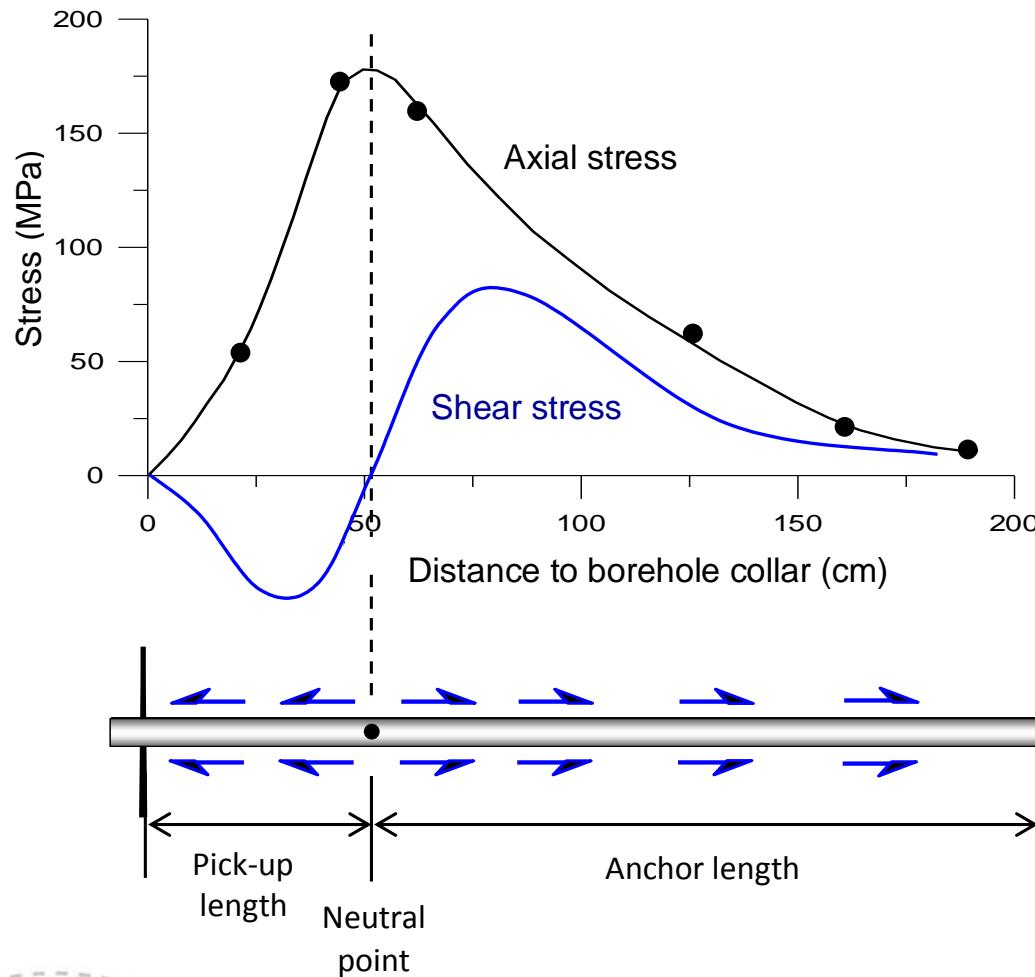
Modeller for enrgibolter



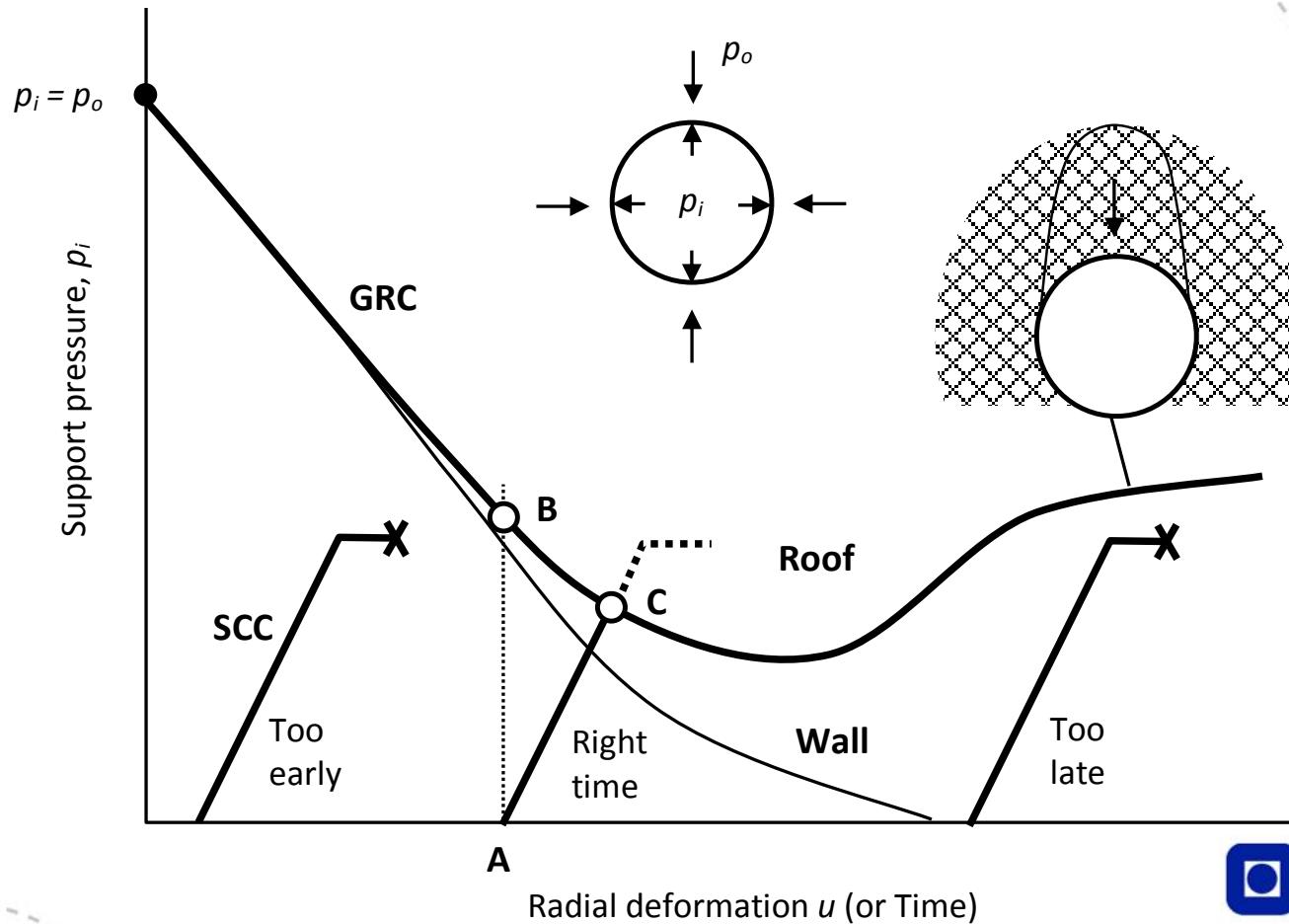
Interaksjon mellom bolter og bergmassen



Interaksjon mellom bolter og bergmassen



Bergmasseresponsekurven og bergsikringslinjen



Kap 5: Boltingsplanlegging

- Bergbruddtyper
- Bergspenningsforhold
- Planleggingsprinsipper
- Typer av bolting

Bergbruddtyper



Blokkfall



Skjærbrudd



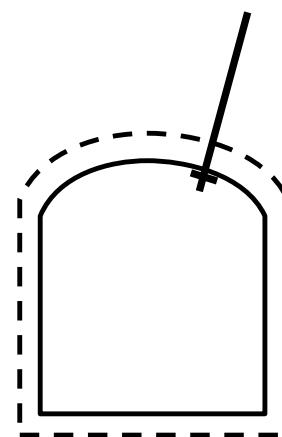
Spraking



Bergslag (rockburst)

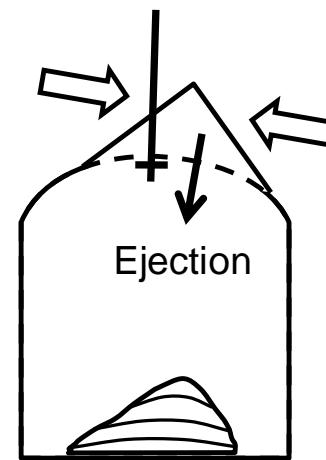
Bergspenningsforhold

Lav spenning

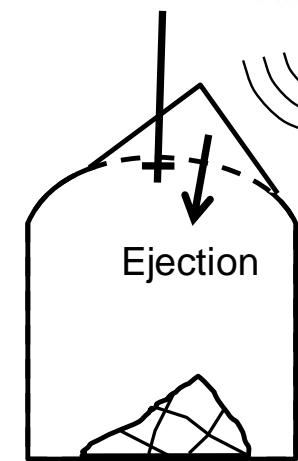


(a)

Høy spenning

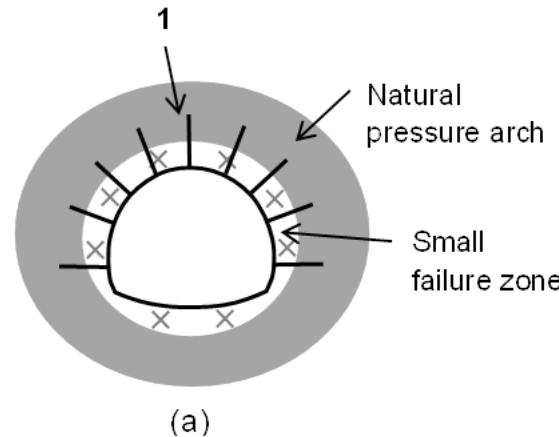


(b)

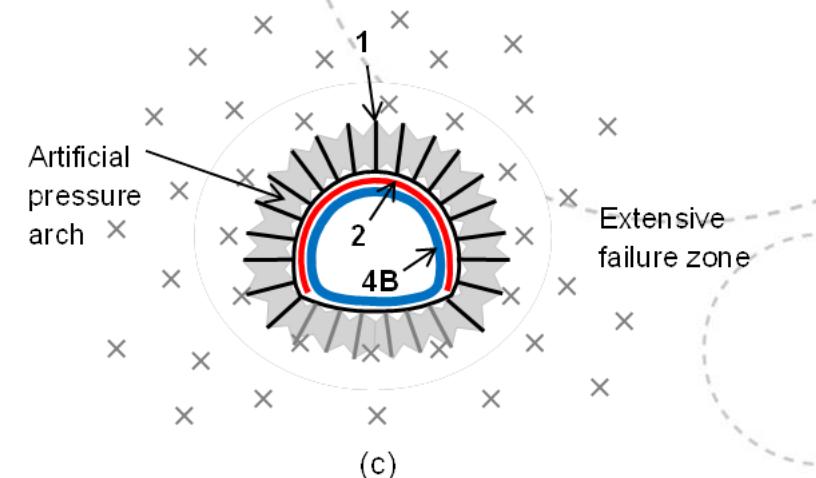


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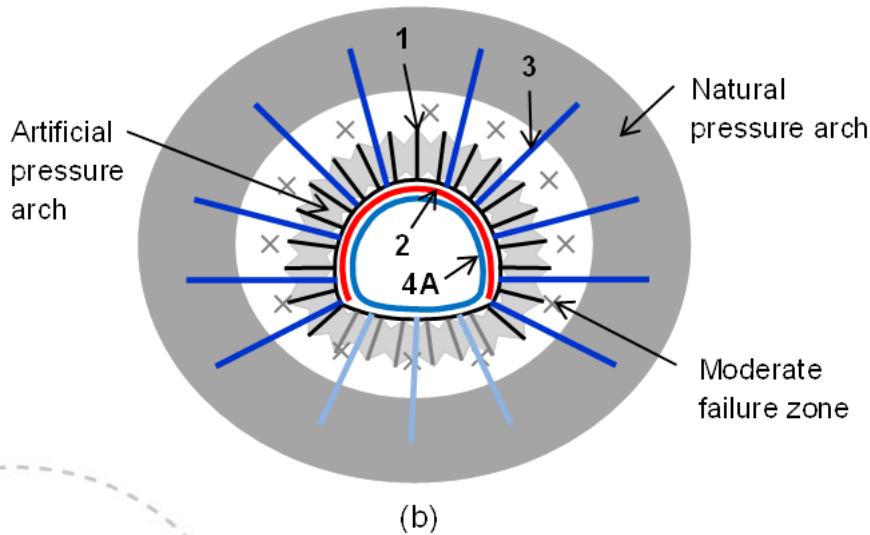
Planleggingsprinsipper



(a)



(c)



(b)

Layer 1 - Bolting: sporadic or systematic
 Layer 2 - Surface retaining: mesh, shotcrete, etc
 Layer 3 - Cable bolting
 Layer 4 - External support: steel sets, concrete arches, concrete lining

Typer av bolting

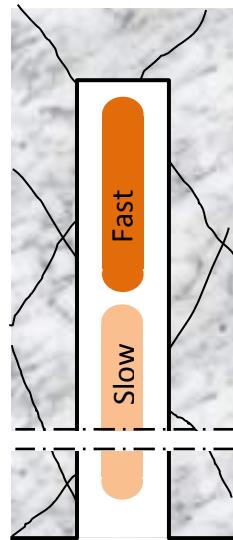
- Kilblokkefesting
- Buebygging
- Suspensjonbolting
- Skjermbolting
- Dynamiskbolting
-

Andre

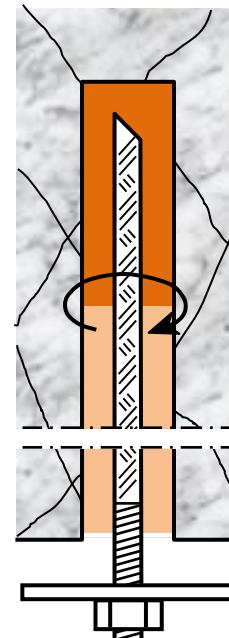
- Bestemmelse av bolte lengden
- Sikkerhetsfaktorer: last, forskyvning, utgitt energi
- Kompatibilitet mellom de ulike sikringselementene i et sikringssystem

Kap 6: Boltinstallasjon

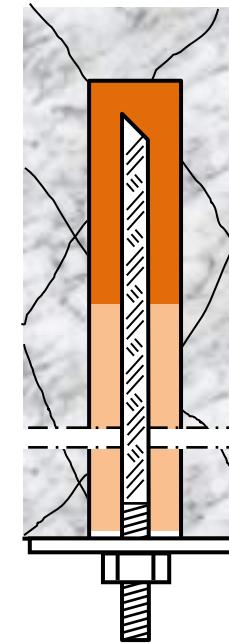
- Installasjonsprosedyre til hver boltype



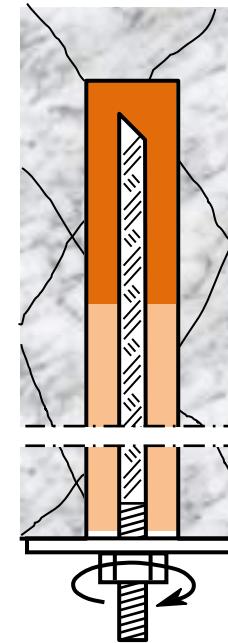
(a)



(b)



(c)

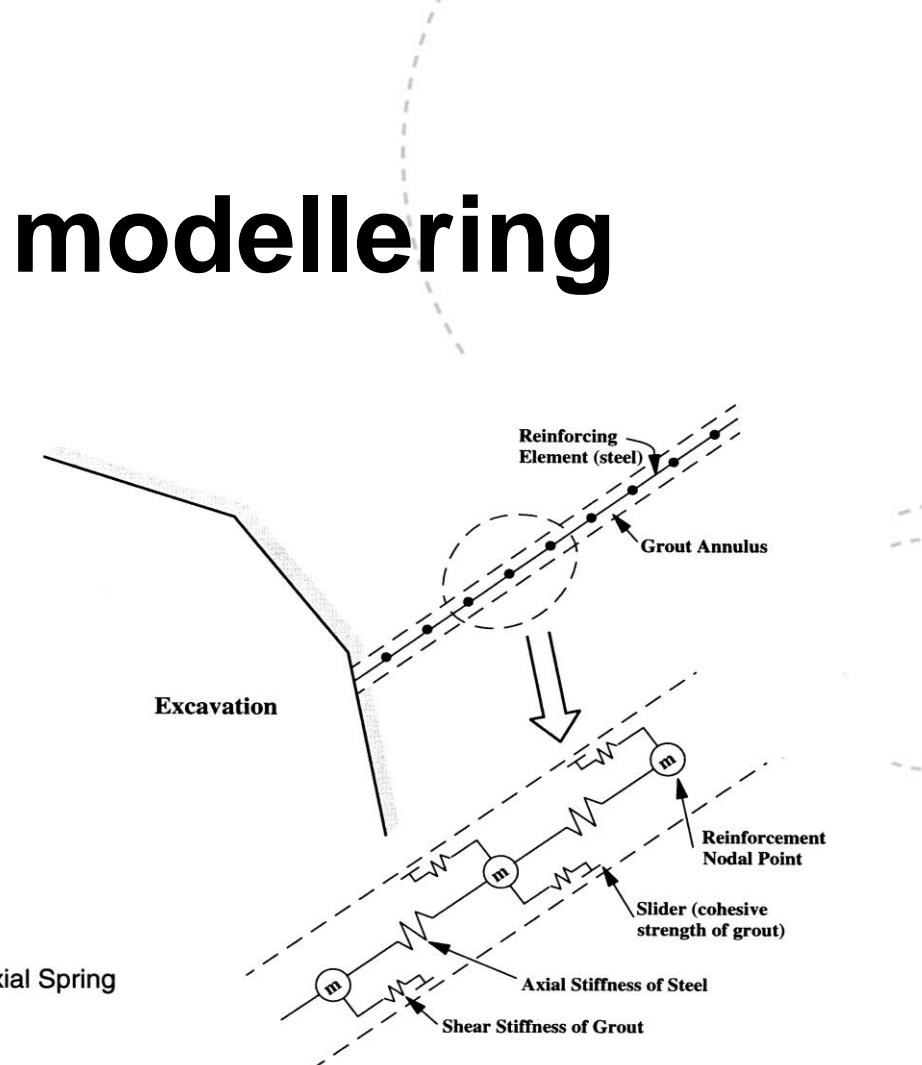
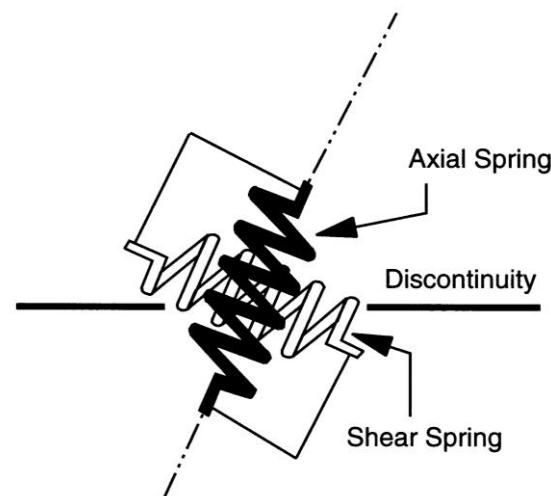
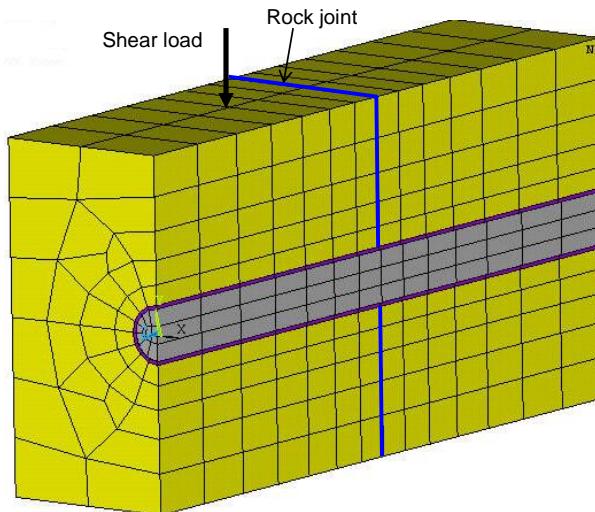


(d)

Kap 7: Kvalitetskontroll

- Kvalitetsprøving: Sjekk produktkvalitet
 - Boltestål
 - Mutter
 - Plater
 - Støppingsmedel
- Design-proof prøving: sjekk om utførelsen av ferdig installerte bolter og tilbehør oppfyller kraven.
 - Strekkprøving (pullout test)
 - Viskositet av sementmørtel
 - Vedheftningsprøving

Kap 8: Numerisk modellering



Kap 9: Eksempler av bolting

- 14 boltingseksempler i ulike bergforhold. 12 fra gruver, 1 vannkraftmaskinhall og Gjørvik hallen
- De fleste er vellykkete kasser. Noen er mislykket.
- For hver kasse: bergmassekvalitet, bergspenningsforhold, bergsikring, hva som skjedde, hvordan boltene reagerte, og konsekvensen



Takk
for oppmerksomheten