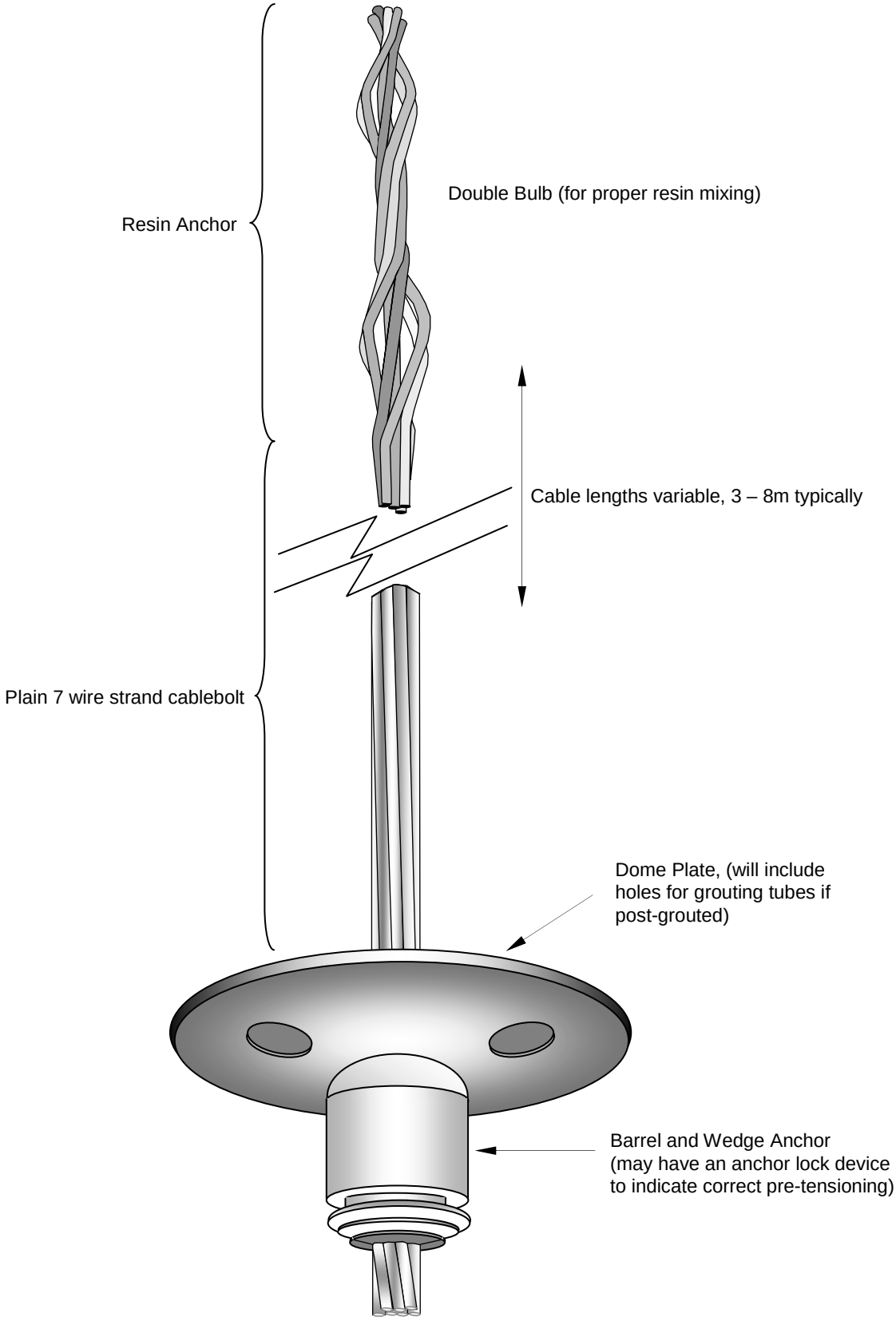
CHAPTER 2



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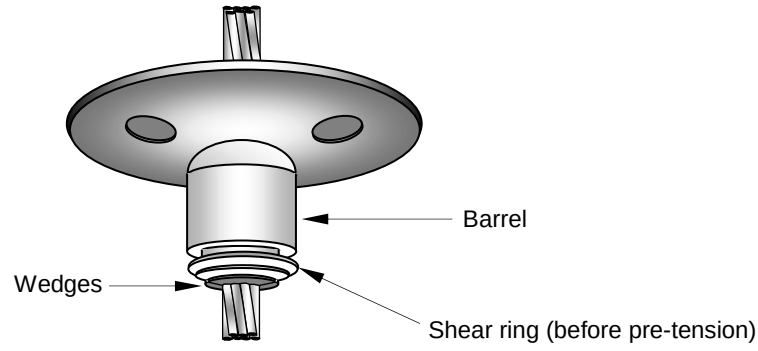
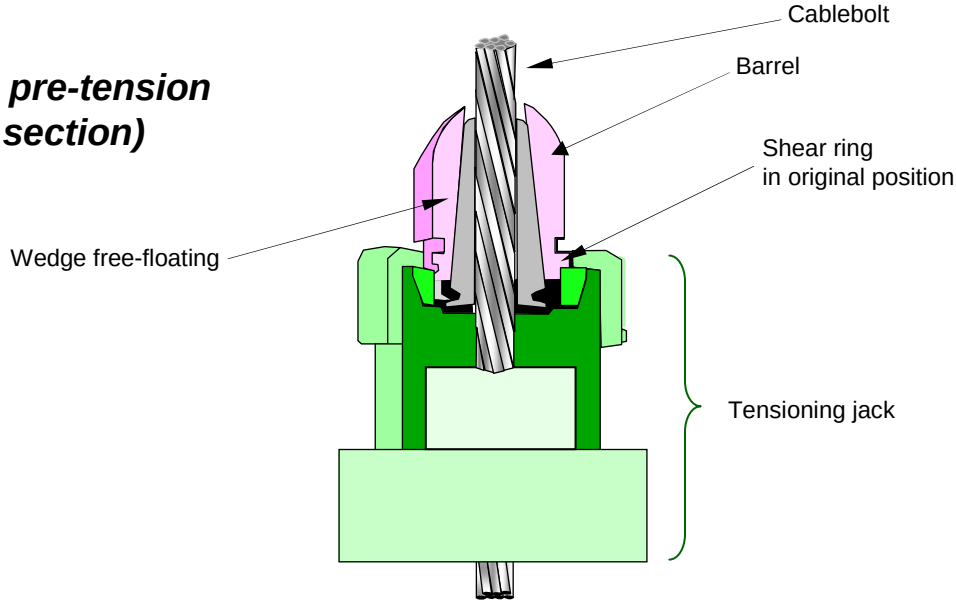
ARRANGEMENT OF A TYPICAL SOUTH AFRICAN CABLEBOLT SYSTEM

FIGURE 2.1
BCCOL704.ppt

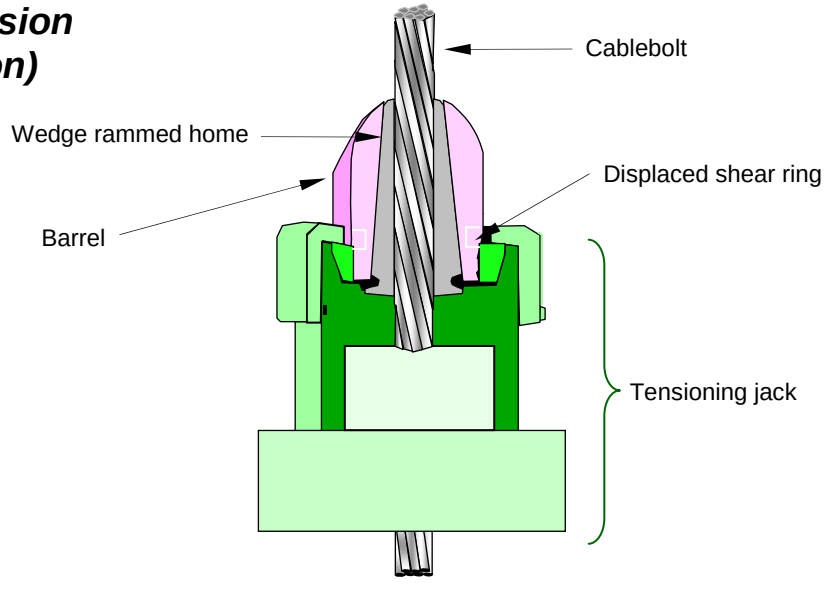
Before pre-tension



Before pre-tension (cross section)



After pre-tension (cross section)



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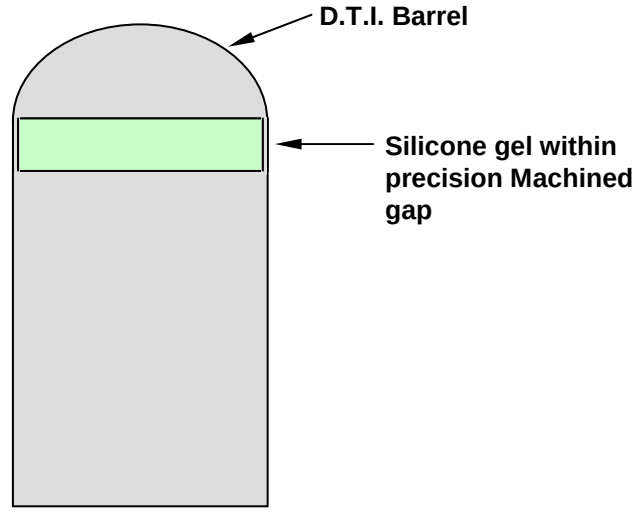
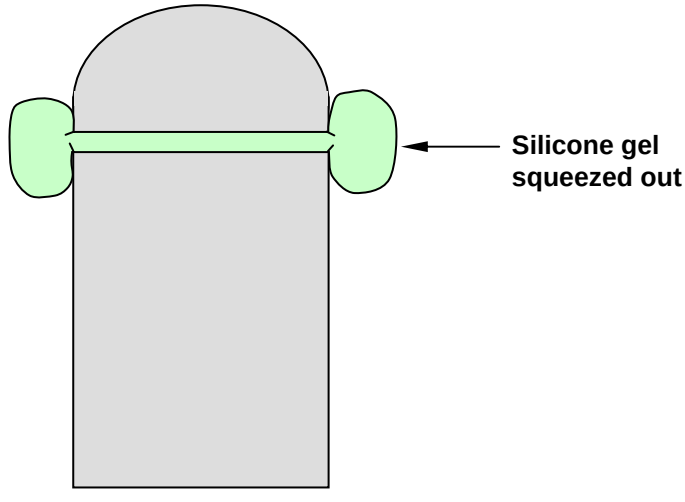
BARREL AND WEDGE ANCHOR SYSTEM WITH THE "SUPERLOCK" ANCHOR LOCKING DEVICE (from Amalgamated Reinforcement)

FIGURE 2.2
BCCOL704.ppt

Before pre-tension



After pre-tension (fully loaded to required pre-tension)



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BARREL OF A BARREL AND WEDGE ANCHOR WITH THE D.T.I. DIRECT TENSION INDICATOR (from M & J Mining)

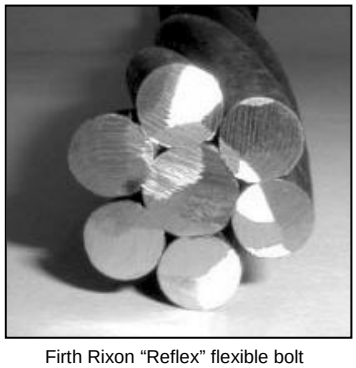
FIGURE 2.3
BCCOL704.ppt

FIGURE 2.4 SOUTH AFRICAN CABLEBOLTS IN-SITU

FIGURE 2.5 SOUTH AFRICAN CABLEBOLTS IN-SITU

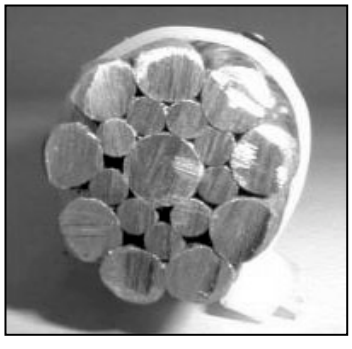
CHAPTER 3

FIGURE 3.1 SINGLE 7 WIRE DYFORM STRAND (top)
SINGLE BIRDCAGED CABLEBOLT (centre)
DOUBLE BIRDCAGED CABLEBOLT (bottom)

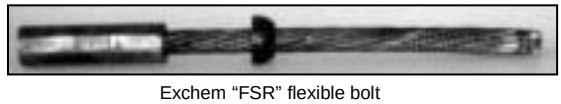


Firth Rixon "Reflex" flexible bolt

Firth Rixon "Reflex" flexible bolt

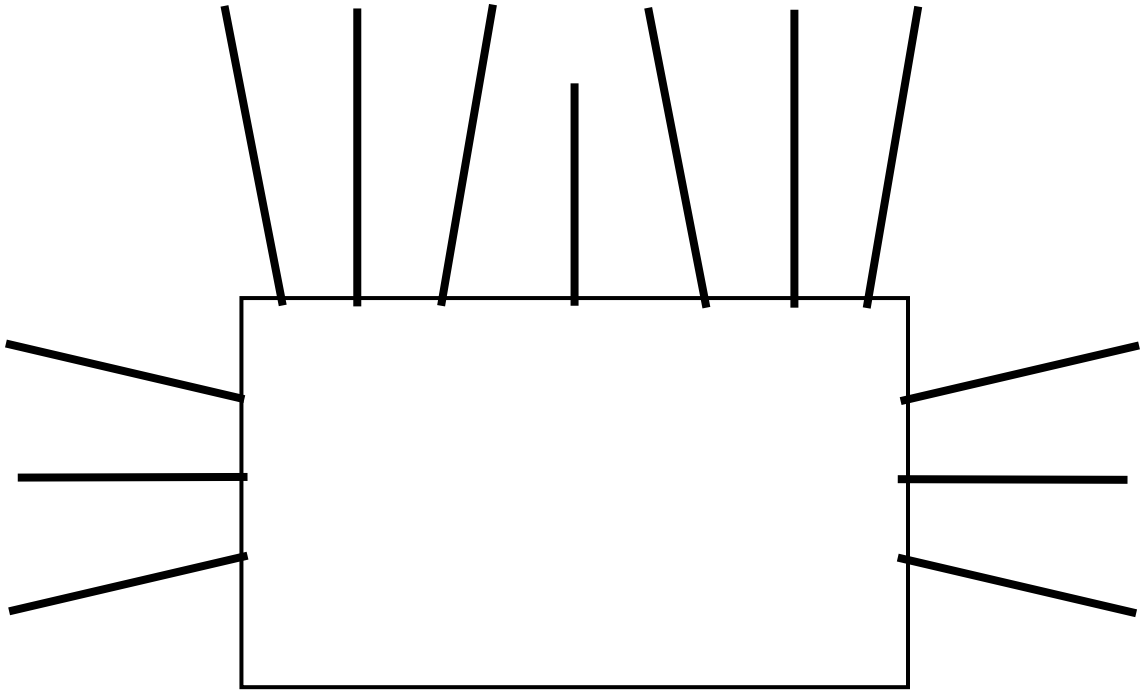


Exchem "FSR" flexible bolt

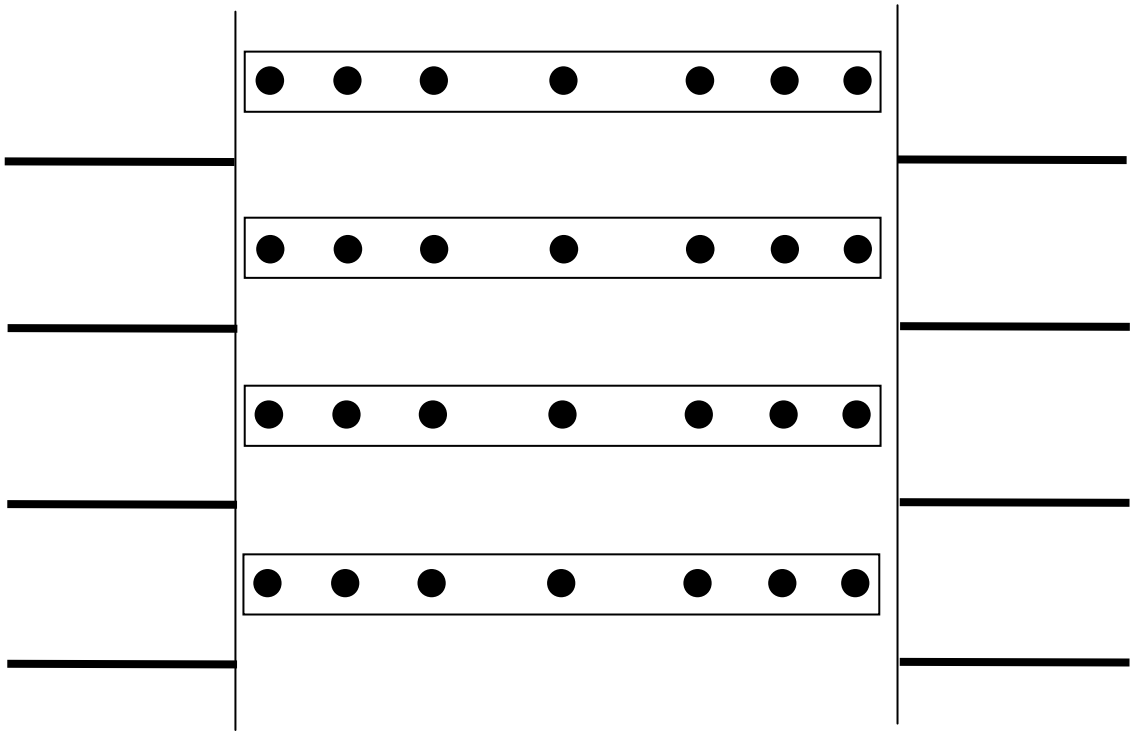


Exchem "FSR" flexible bolt

FIGURE 3.2 PHOTOGRAPHS OF THE TWO TYPES OF FLEXIBLE-BOLT USED IN UK COAL MINES



CROSS SECTION



PLAN

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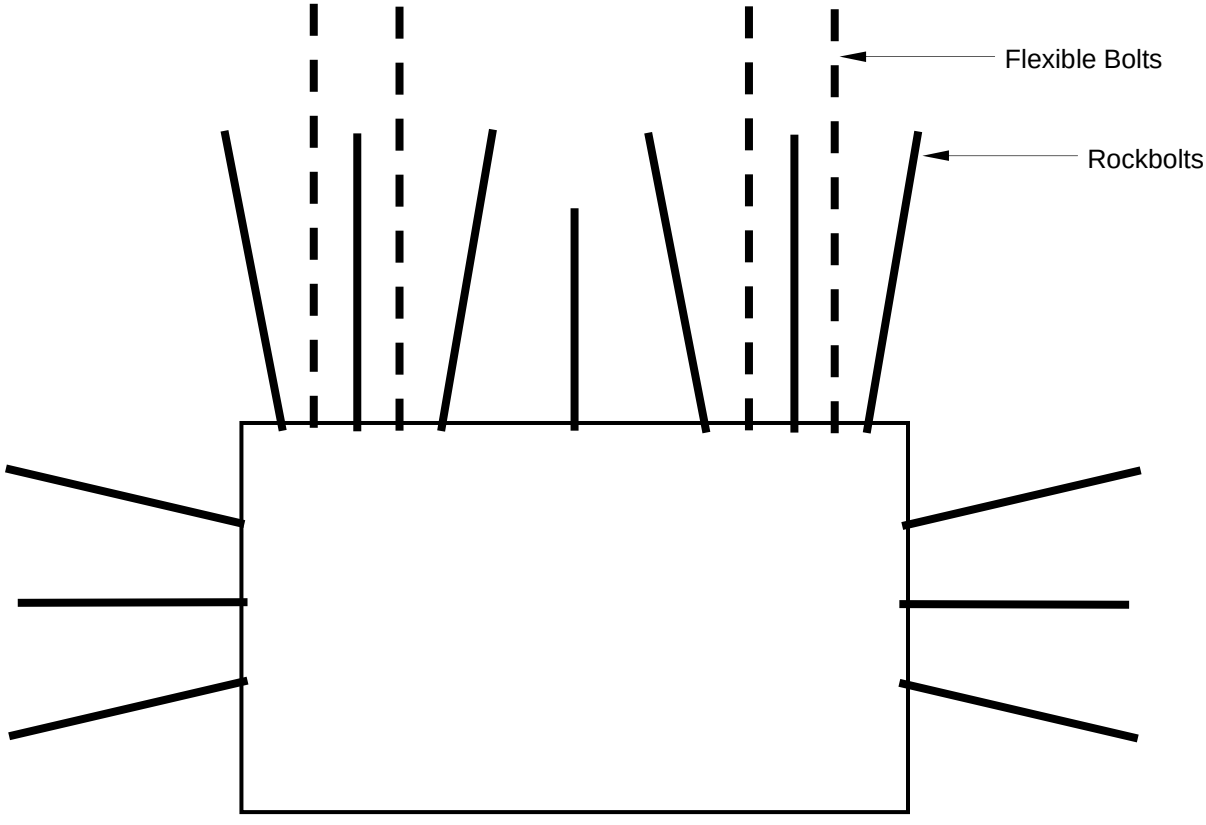
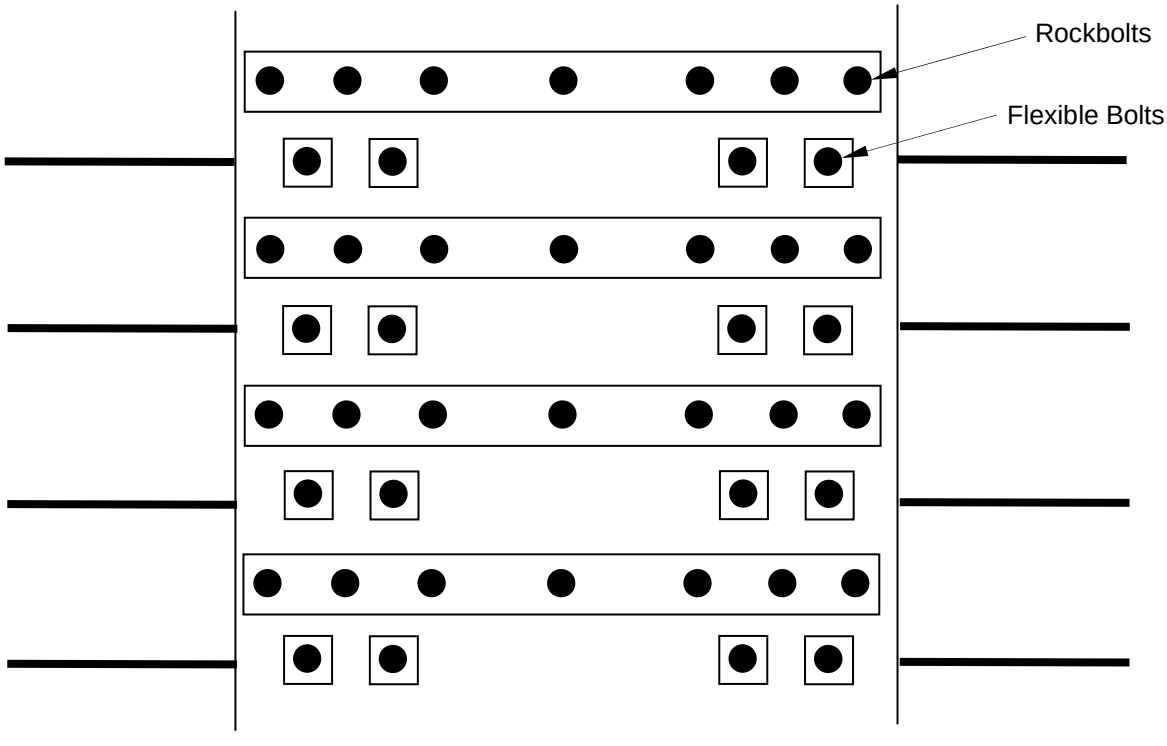
BOLTER MINER PATTERN USED FOR HIGH DEFORMATION SITE USING ONLY ROCKBOLTS

FIGURE 3.3
BCCOL704.ppt



CROSS SECTION



PLAN

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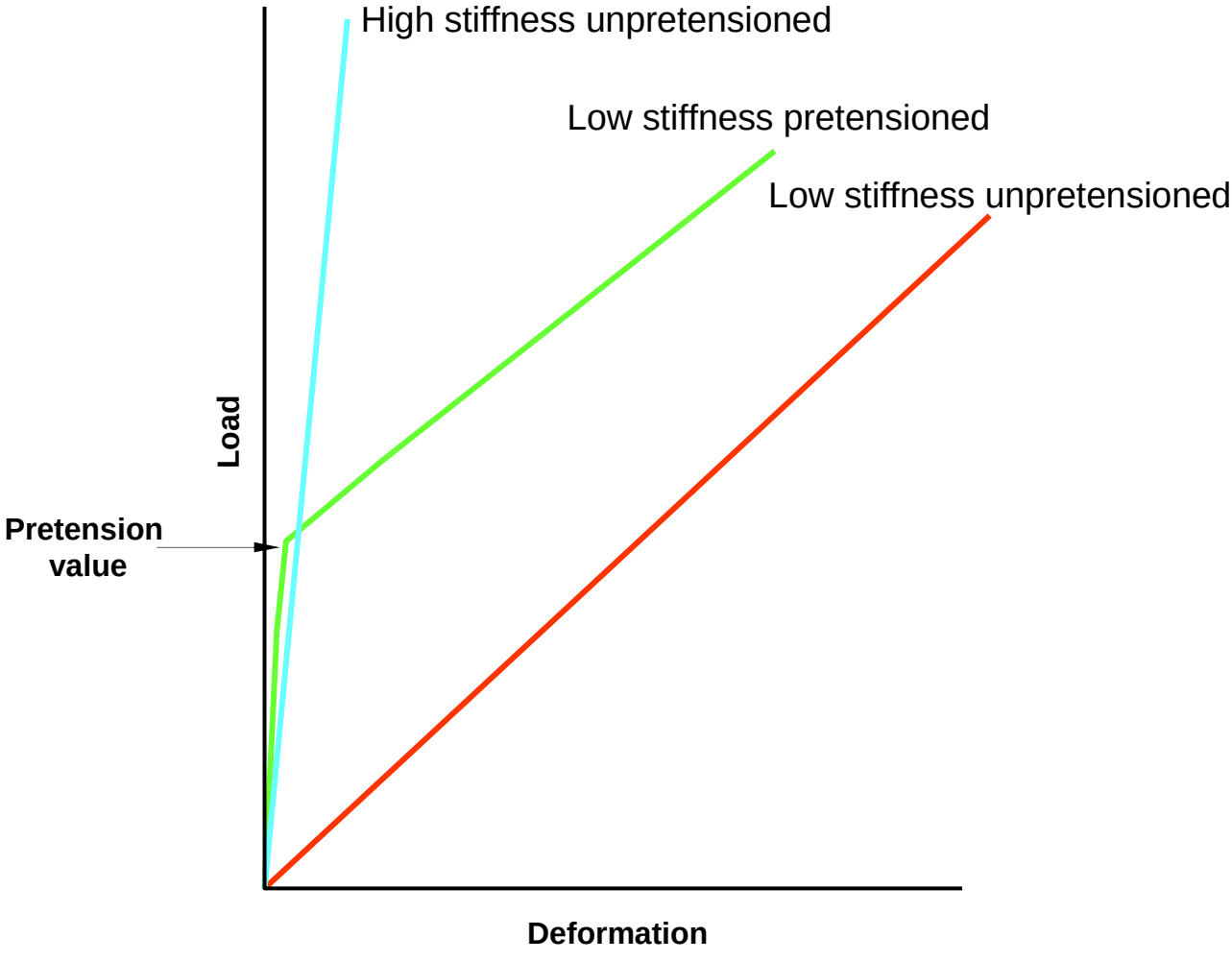
BOLTER MINER PATTERN USED FOR HIGH DEFORMATION SITE COMPRISING ROCKBOLTS AND FLEXIBLE BOLTS

FIGURE 3.4

BCCOL704.ppt



GENERAL EFFECT OF PRETENSIONING ON REINFORCEMENT STIFFNESS

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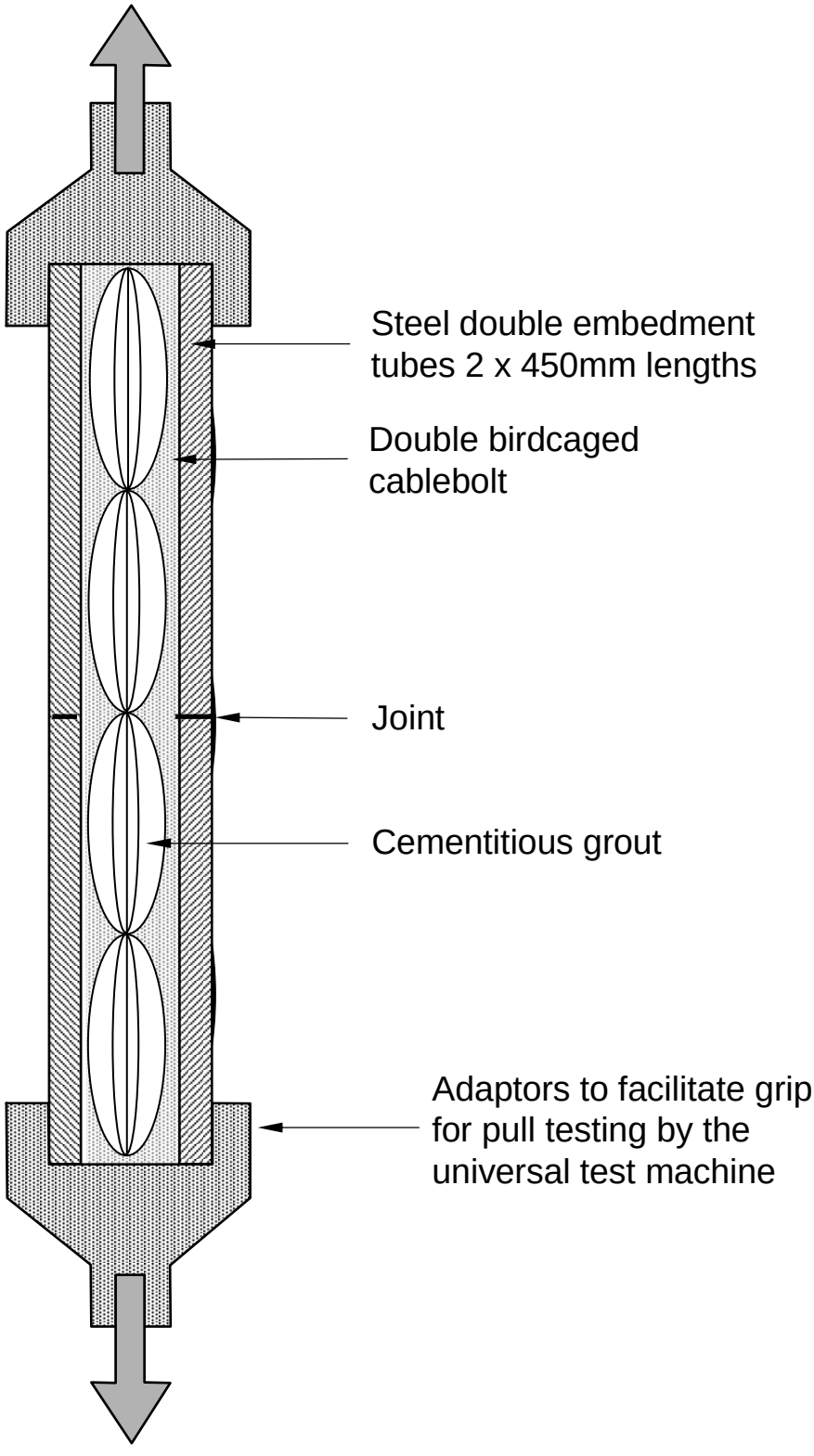
FIGURE 3.5
BCCOL704.ppt



AXIAL DOUBLE EMBEDMENT TEST ASSEMBLY

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FIGURE 3.6
BCCOL704.ppt

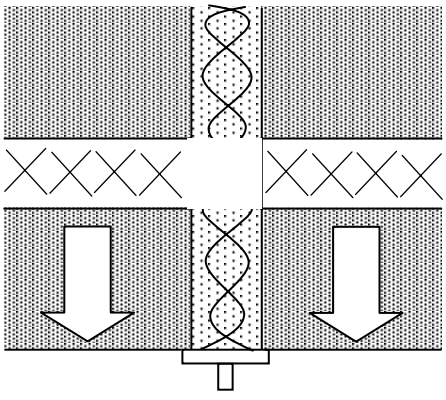

Figure 3.7 (a) Tendon failure in tension

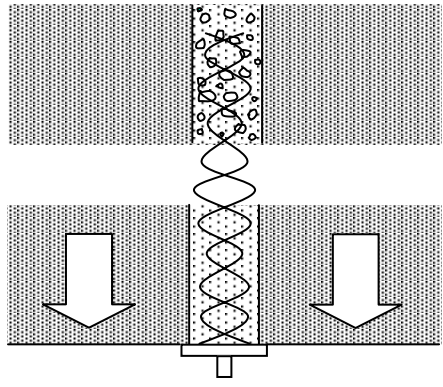

Figure 3.7 (b) Shear failure through the grout or at grout / tendon interface

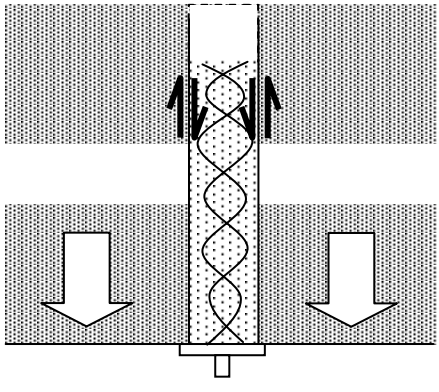

Figure 3.7 (c) Shear failure at the grout hole / boundary

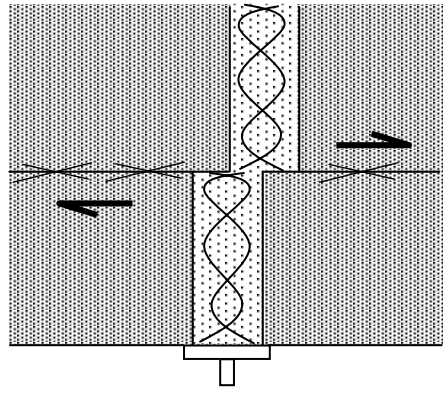

Figure 3.7 (d) Tendon failure in shear

FAILURE MODES FOR A GROUTED TENDON

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FIGURE 3.7
BCCOL704.ppt

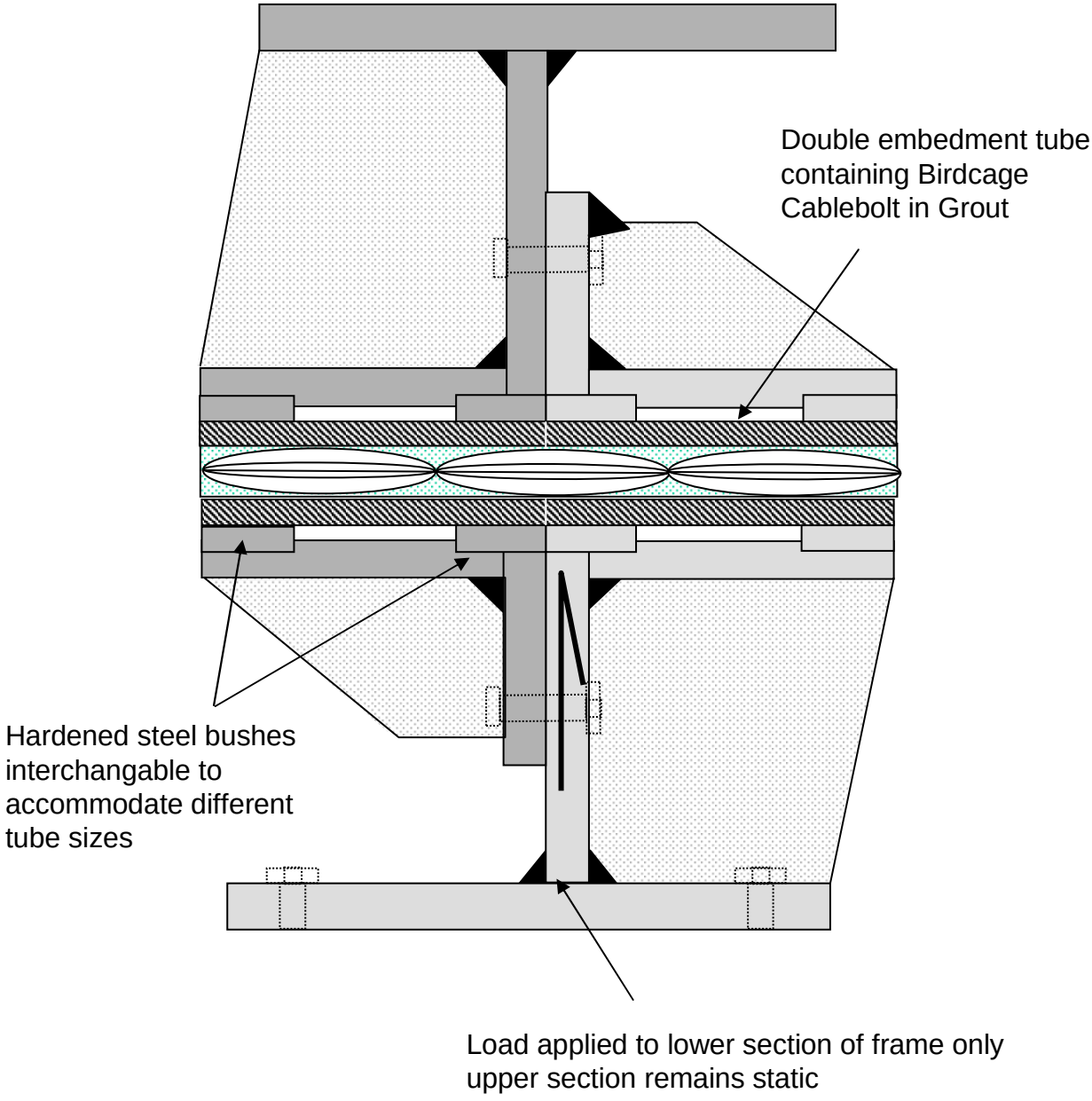

DIAGRAM OF SHEAR FRAME FOR STEEL CABLEBOLT/GROUT SYSTEM

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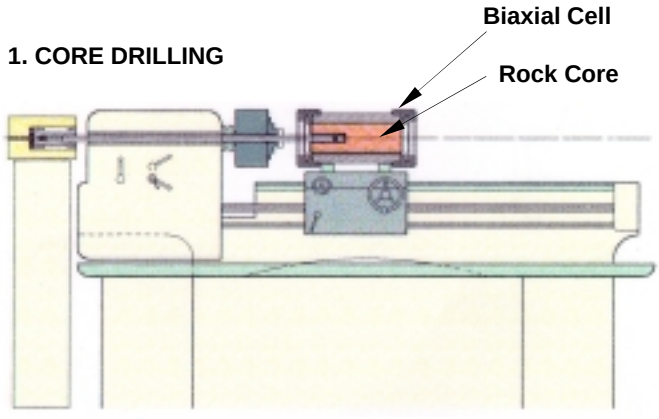
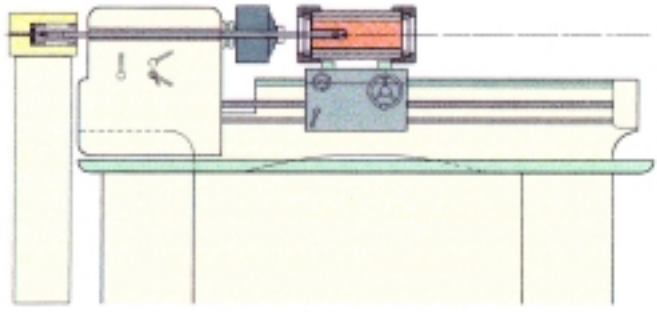
FIGURE 3.8
BCCOL704.ppt

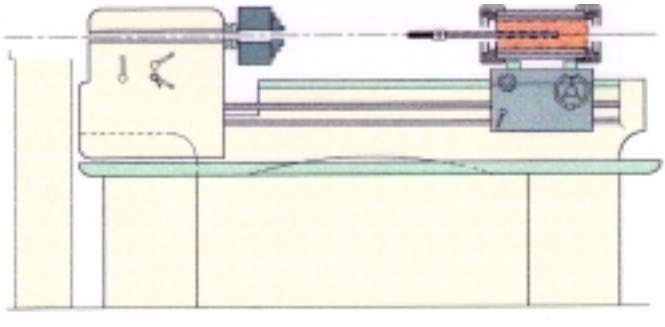
1. CORE DRILLING

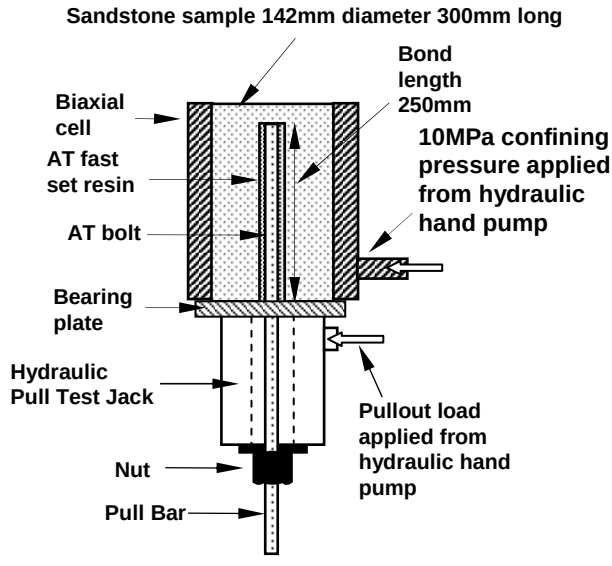


2. PREPARATION FOR BOLT INSTALLATION

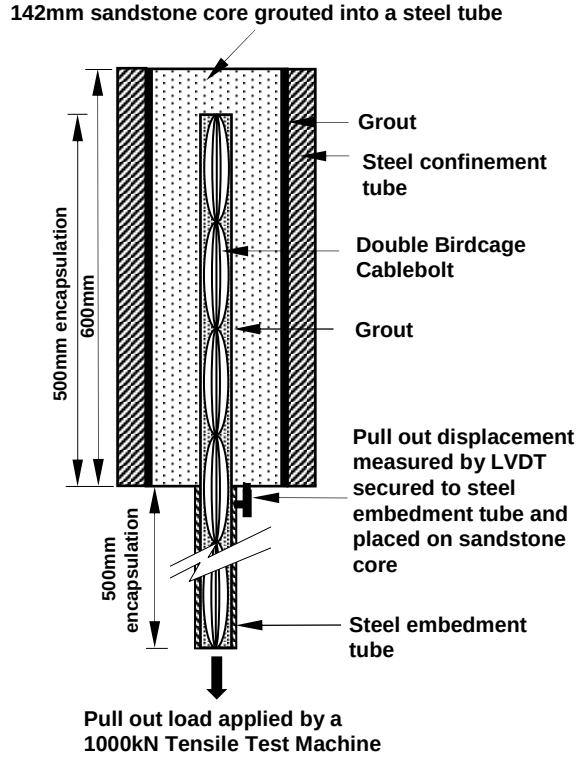


3. BOLT INSTALLATION READY FOR PULL TESTING





(a) ROCKBOLT / RESIN SET-UP



(b) TENDON / GROUT SET-UP

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SCHEMATIC DIAGRAM OF THE LABORATORY SHORT ENCAPSULATION PULL TEST FOR (a) ROCKBOLT/RESIN (b) TENDON GROUT

FIGURE 3.9

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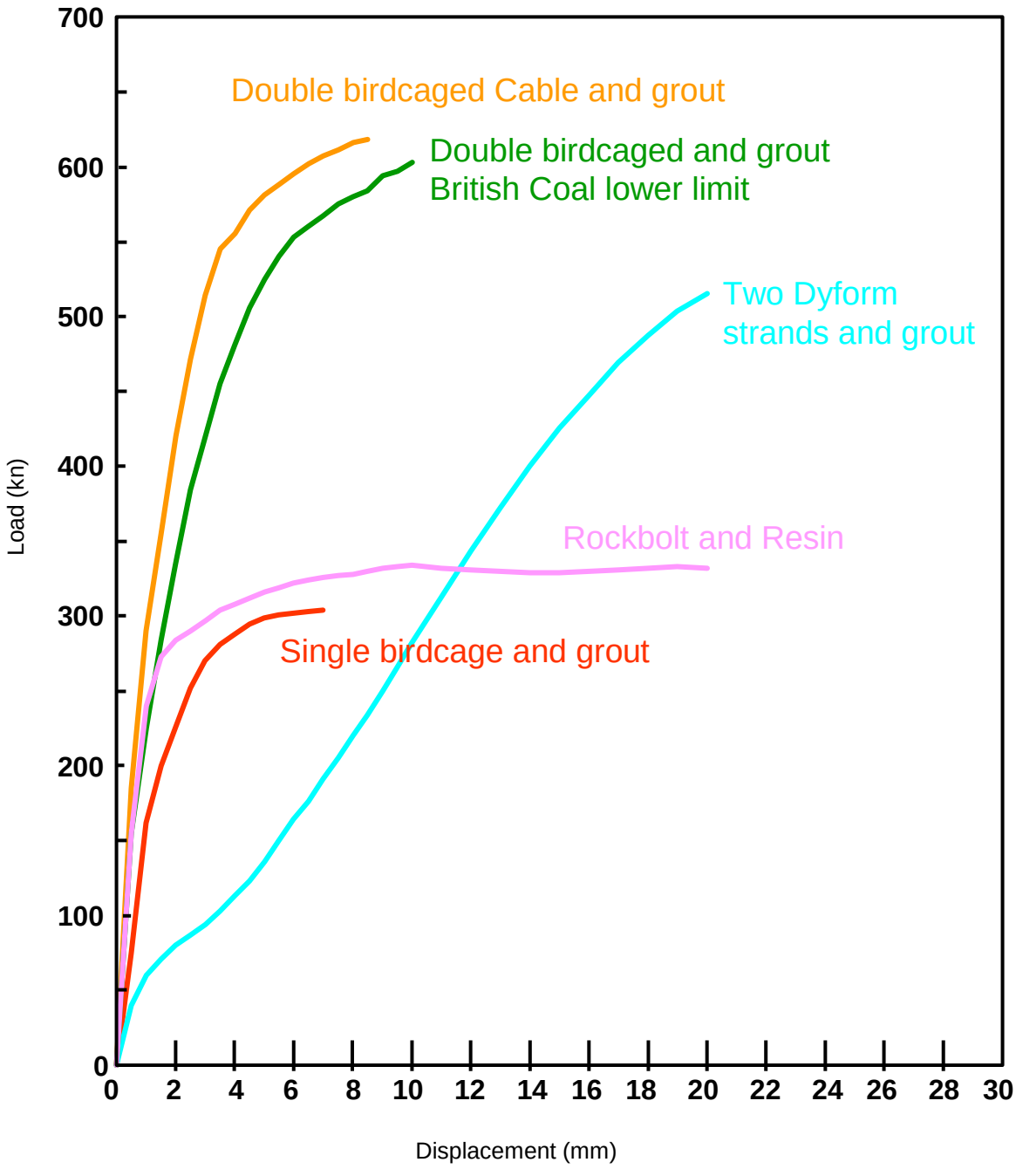

AXIAL REINFORCEMENT PERFORMANCE OF THE ROCKBOLT, DYFORM STRAND AND SINGLE AND DOUBLE BIRDCAGED CABLEBOLTS DETERMINED BY THE DOUBLE EMBEDMENT PULL TEST METHOD

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FIGURE 3.10
BCCOL704.ppt

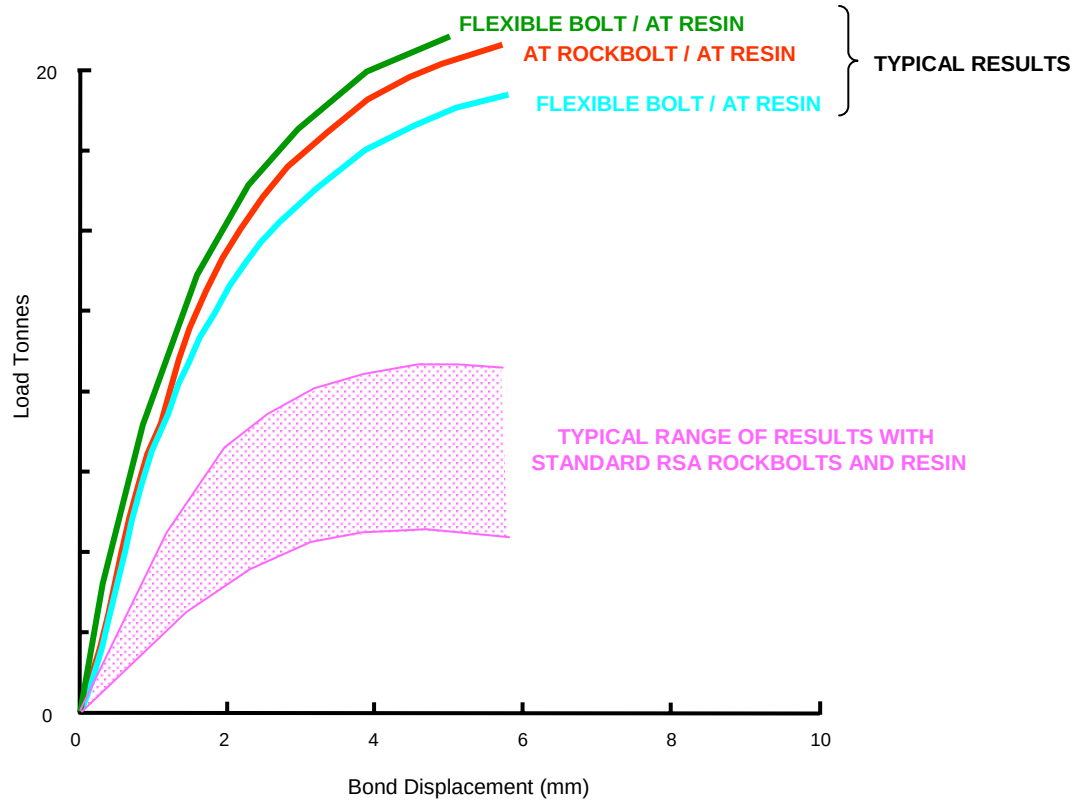

FIGURE 3.11 TYPICAL SHORT ENCAPSULATION PULL TESTS IN CONFINED SANDSTONE (250mm EMBEDMENT LENGTH)

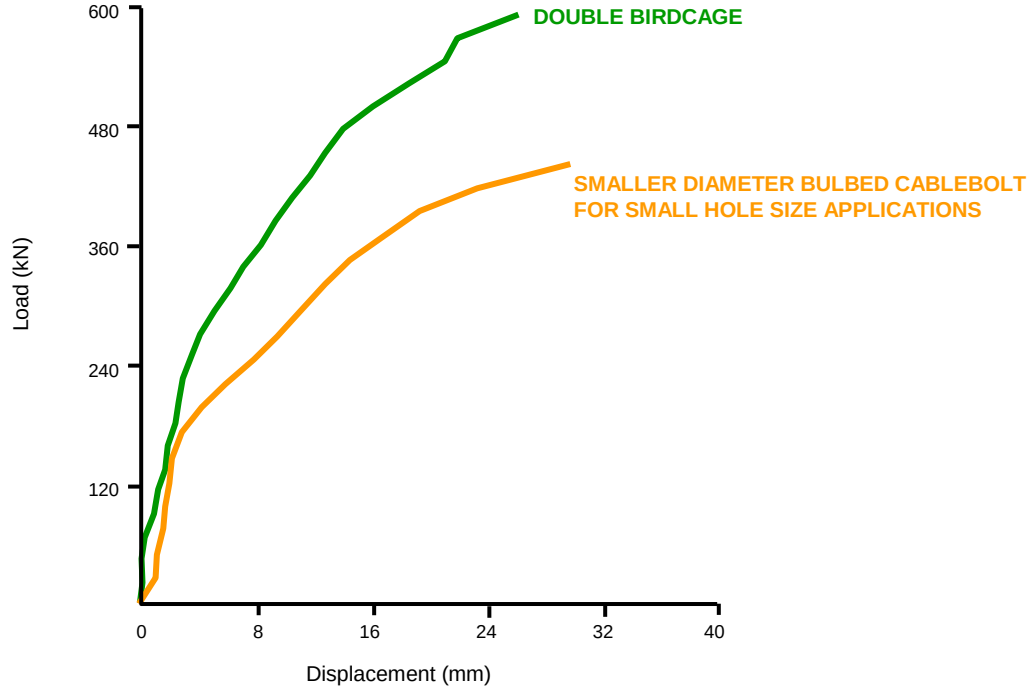

FIGURE 3.12 LABORATORY SHORT ENCAPSULATION PULL TEST RESULTS FOR A DOUBLE BIRDCAGED AND ALTERNATIVE CABLEBOLT IN GROUT IN SANDSTONE CORE (450mm EMBEDMENT LENGTH)

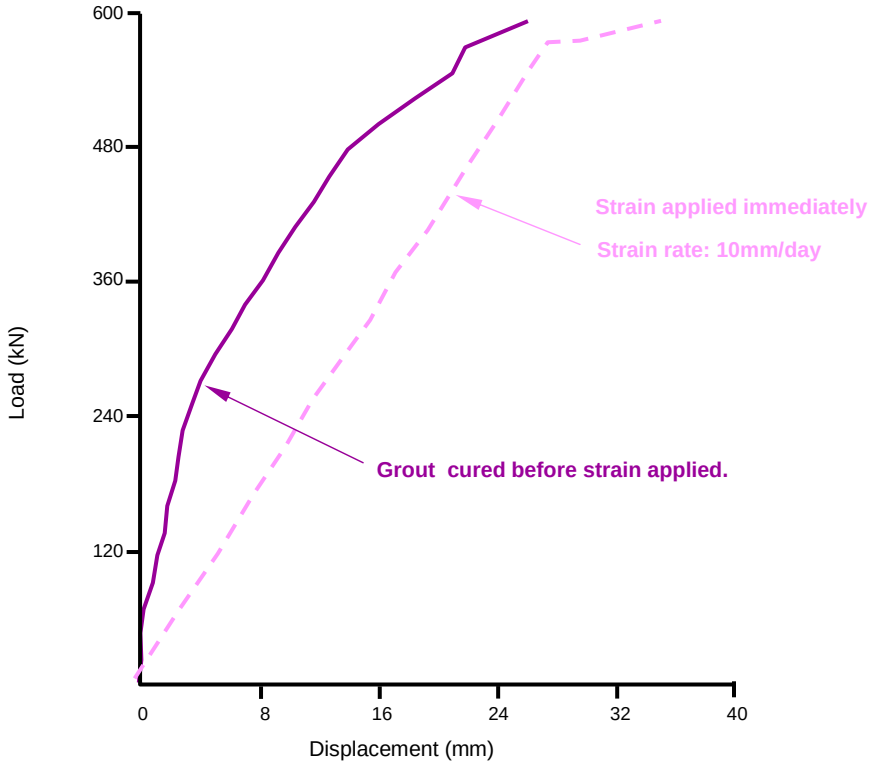

FIGURE 3.13 LABORATORY SHORT ENCAPSULATION PULL TEST RESULTS FOR DOUBLE BIRDCAGED CABLEBOLTS PULLED AT VARIOUS STRAIN RATES IMMEDIATELY AFTER GROUTING (450mm EMBEDMENT LENGTH)

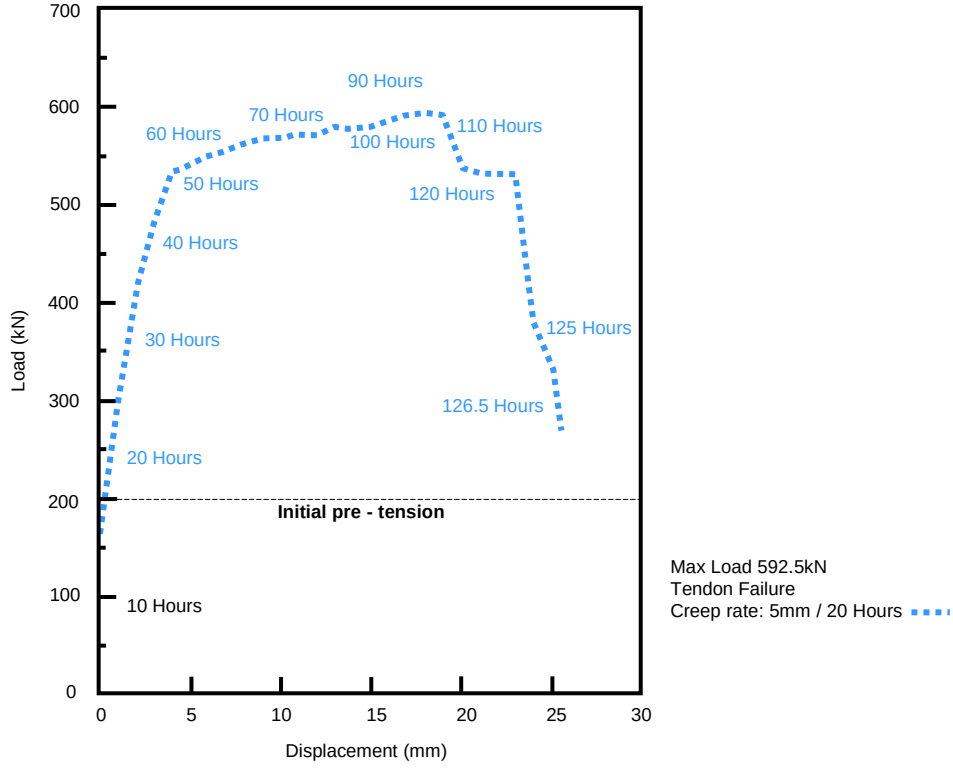

FIGURE 3.14 LABORATORY SINGLE 2.4m LONG ENCAPSULATION PULL TEST ON A PRETENSIONED COMBINED SYSTEM IN SANDSTONE CORE AT A CONSTANT STRAIN RATE

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CHAPTER 4

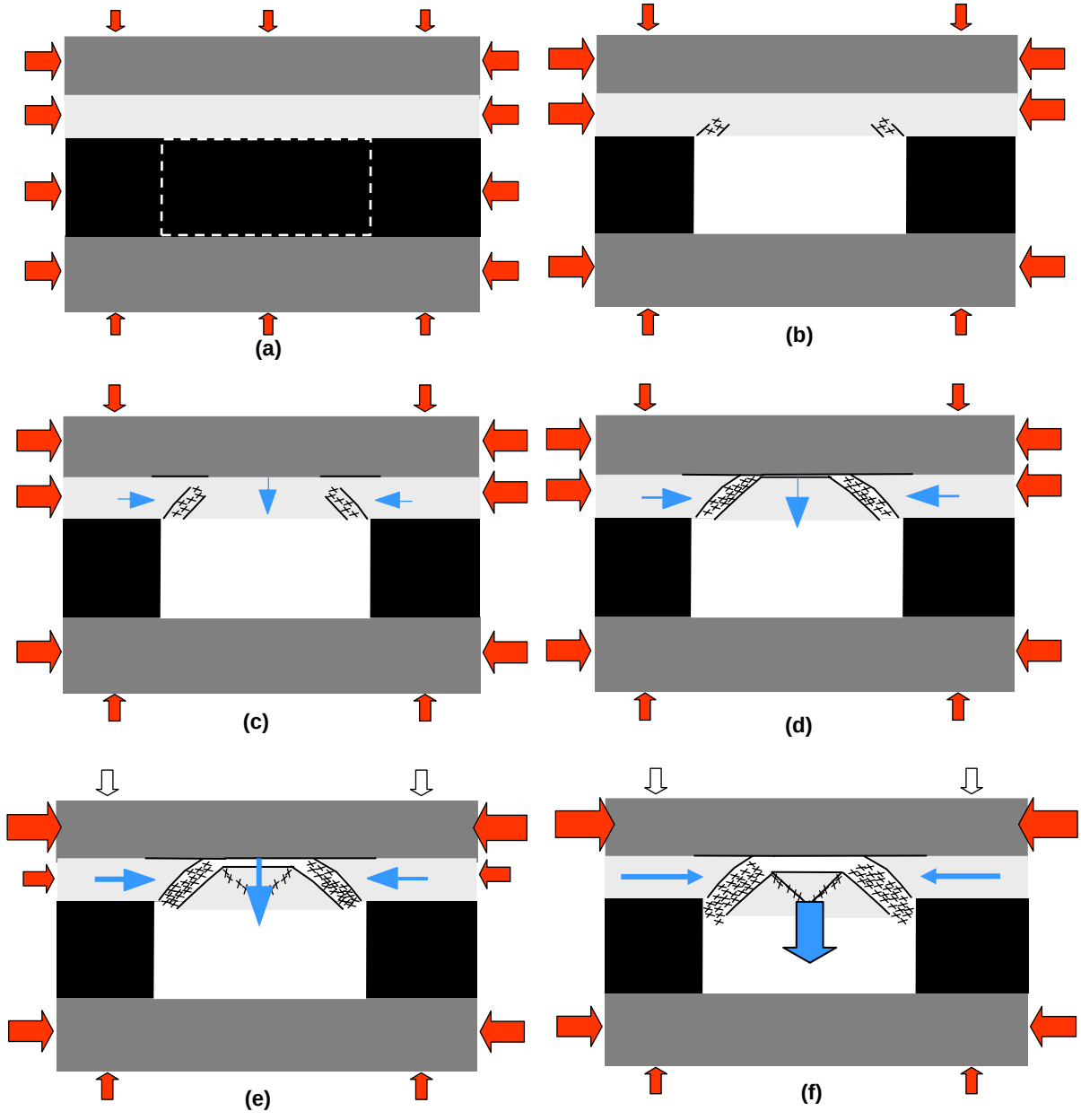

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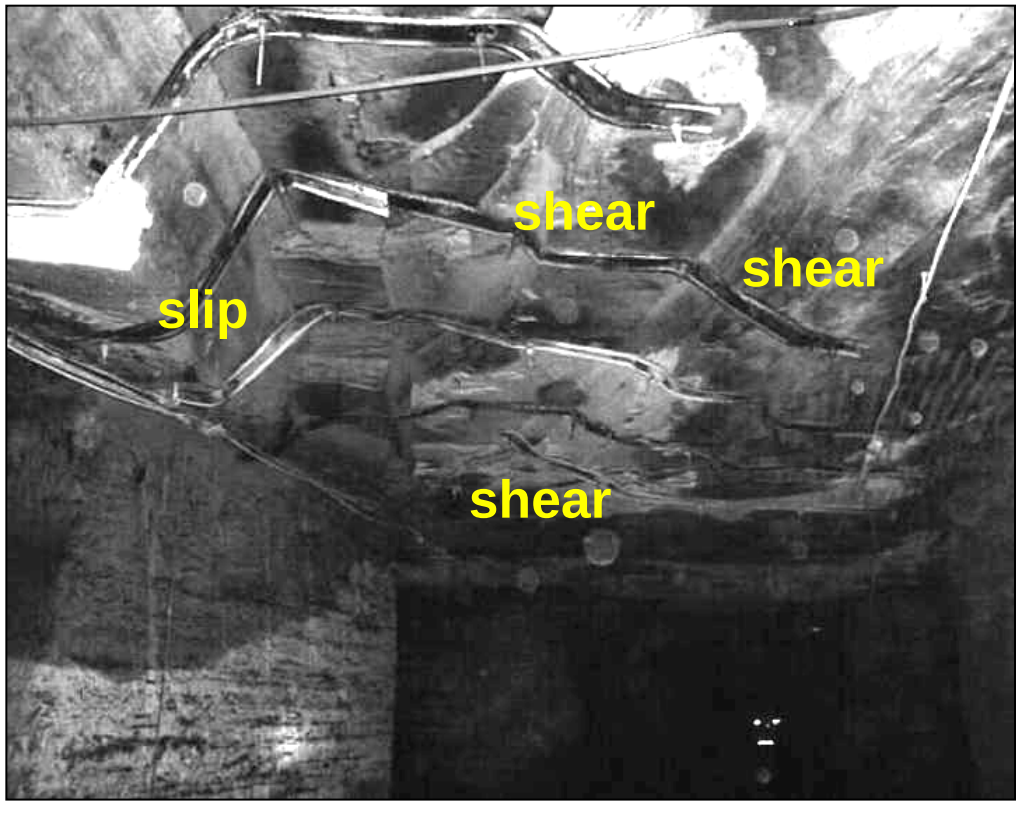
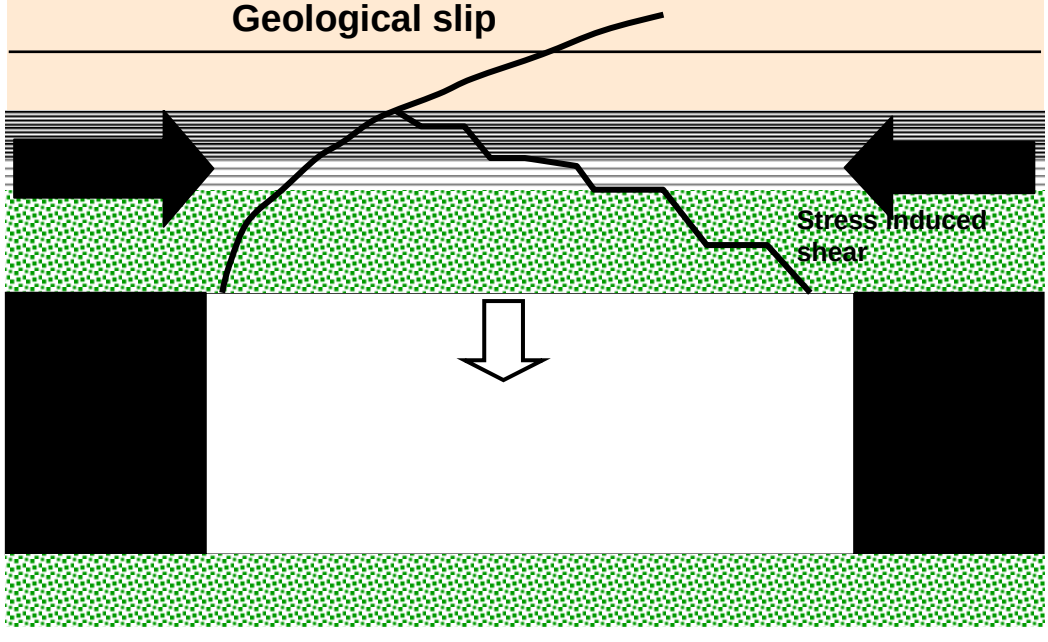
DIAGRAM SHOWING MECHANISM OF ROOF FAILURE DUE TO SHEAR

FIGURE 4.1
BCCOL704.ppt





TYPICAL ROOF FALL INVOLVING A SLIP FEATURE

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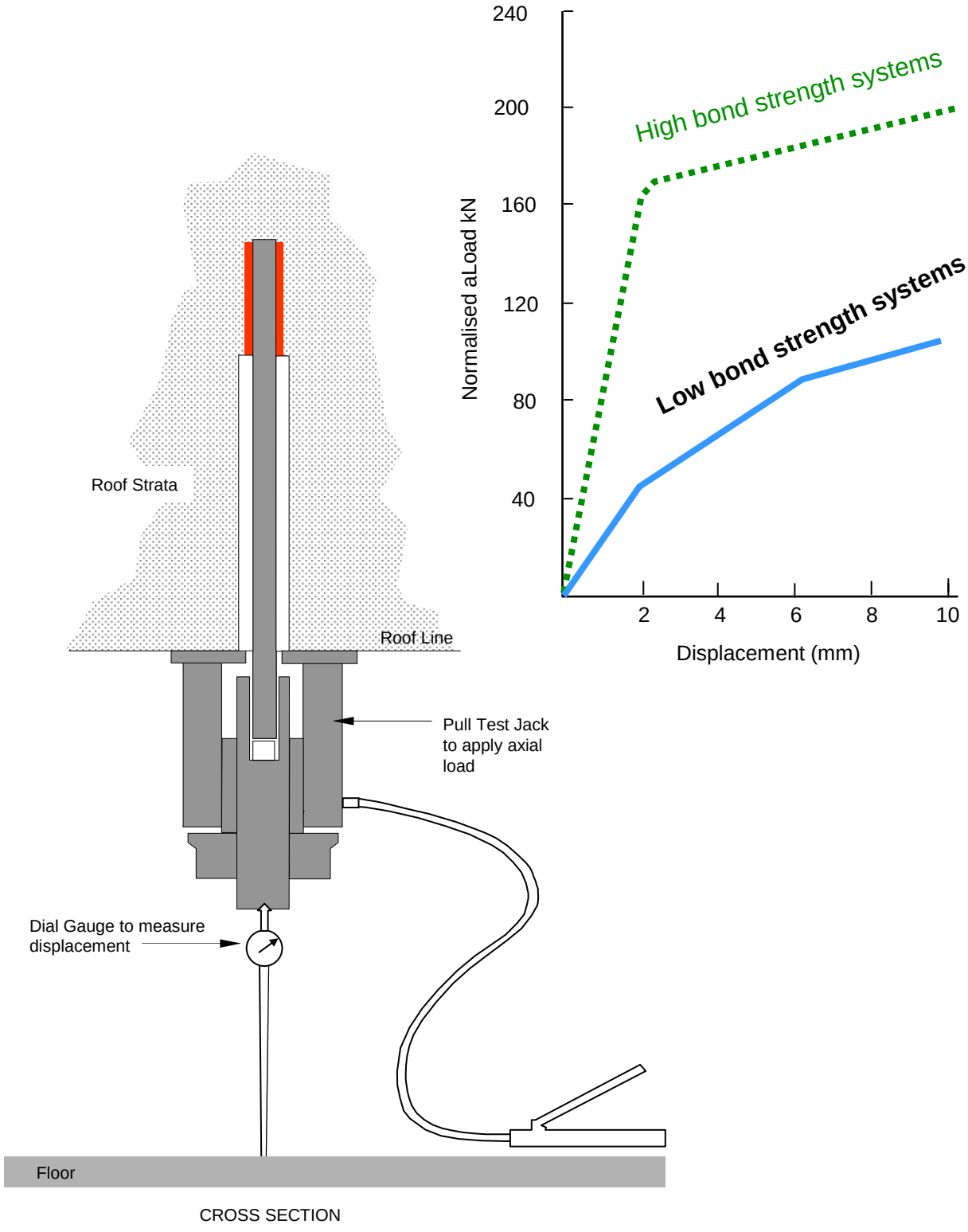
FIGURE 4.2
BCCOL704.ppt



PULL TESTING EQUIPMENT AND TYPICAL RESULTS

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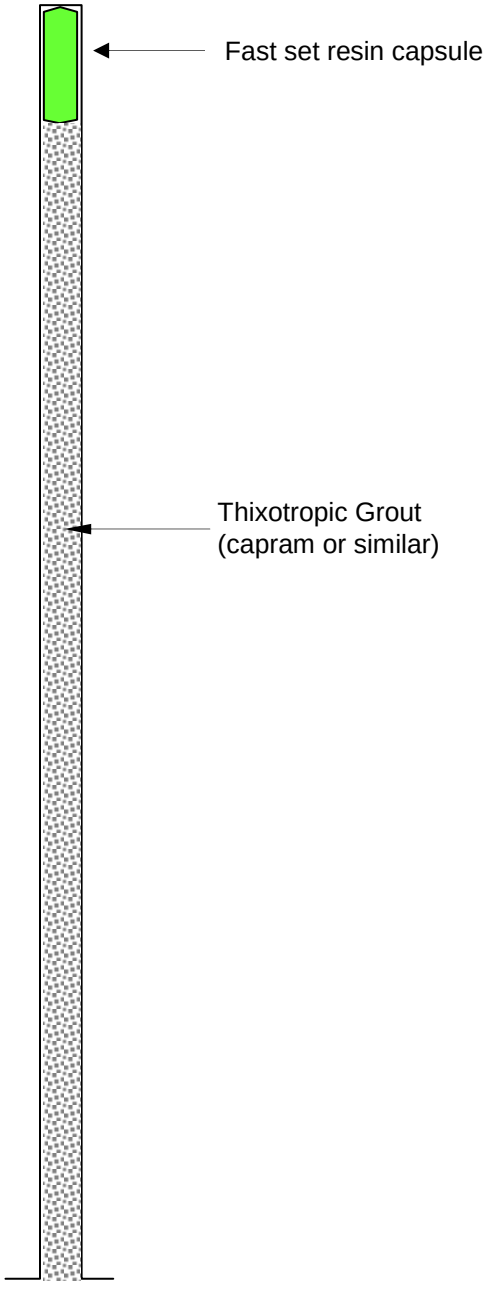
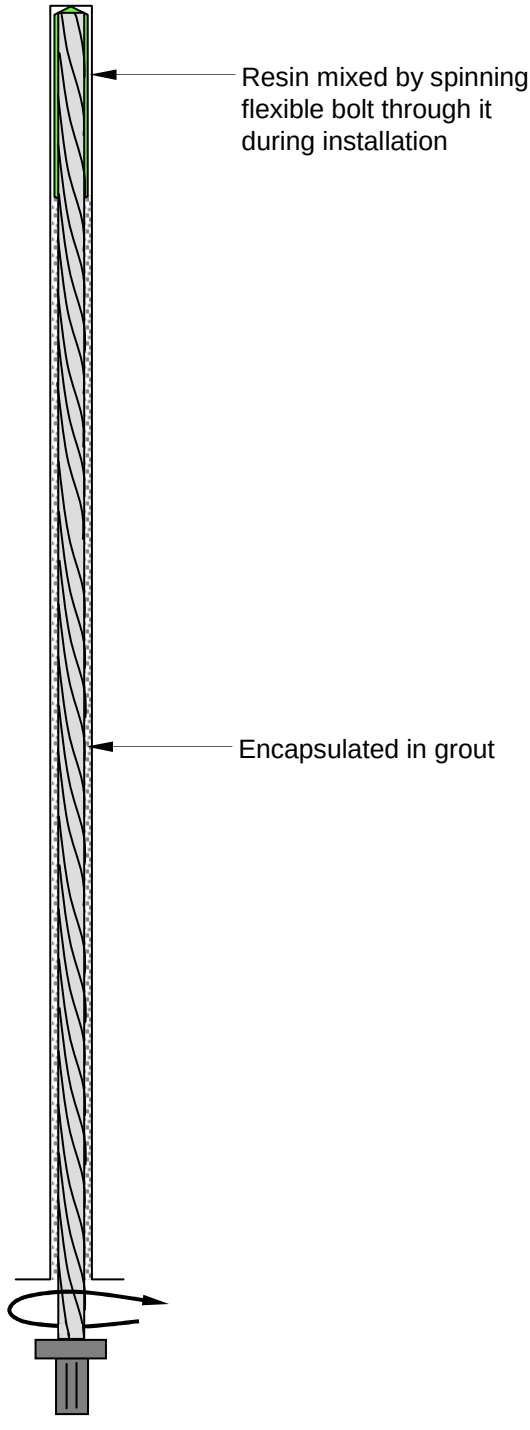
FIGURE 4.3
BCCOL704.ppt





STEP 1

AFTER DRILLING ROOF BOREHOLE RESIN CAPSULE PUSHED TO BACK OF HOLE, THEN REMAINDER OF HOLE FILLED WITH THIXOTROPIC GROUT

STEP 2

THE FLEXIBLE BOLT IS PUSHED THROUGH THE GROUT THEN SPUN THROUGH THE RESIN CAPSULE AND MAY BE PRETENSIONED

INSTALLATION OF FLEXIBLE BOLTS AT LENGTHS GREATER THAN 5m UTILISING COMBINED RESIN AND GROUT ENCAPSULATION

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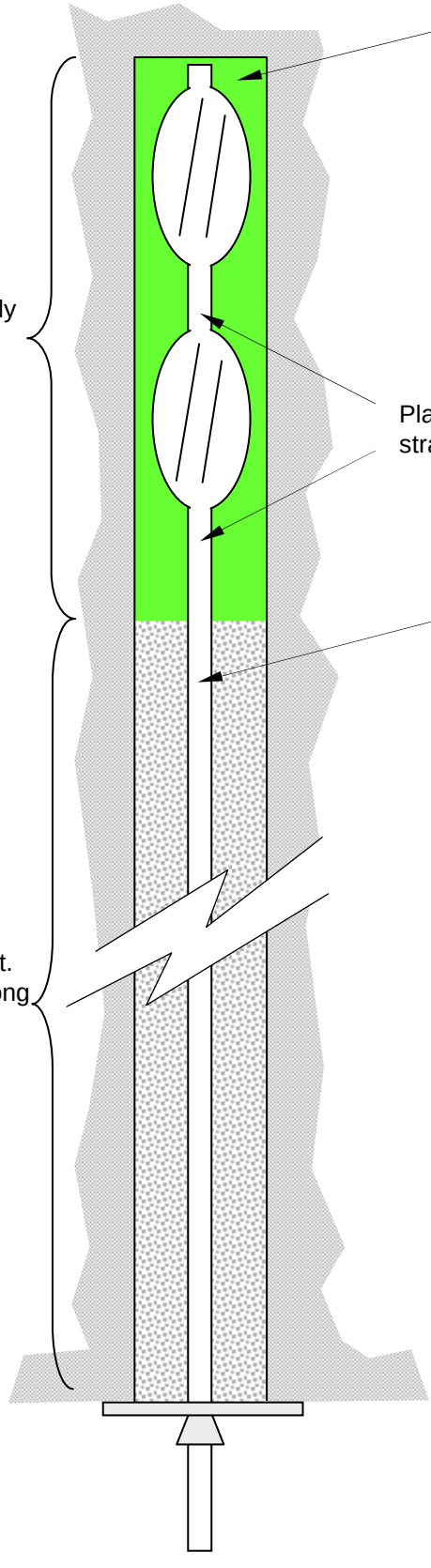
FIGURE 4.4
BCCOL704.ppt

CHAPTER 5

SOUTH AFRICAN CABLE ANCHOR SYSTEM



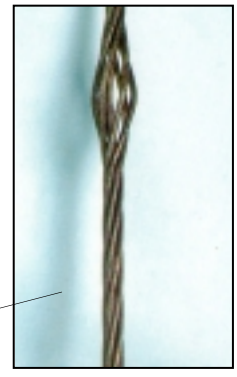
Hole drilled with 36 – 38mm diameter using full spade carbide drill bit

Twin bulbed section of cable spun into resin. This section approximately 0.5m long

Plain unbulbed strand in resin

Unbulbed section of cable anchor back grouted with South African cable bolt grout. This is approximately 5.5m long

Plain smooth strand



Alternative strand

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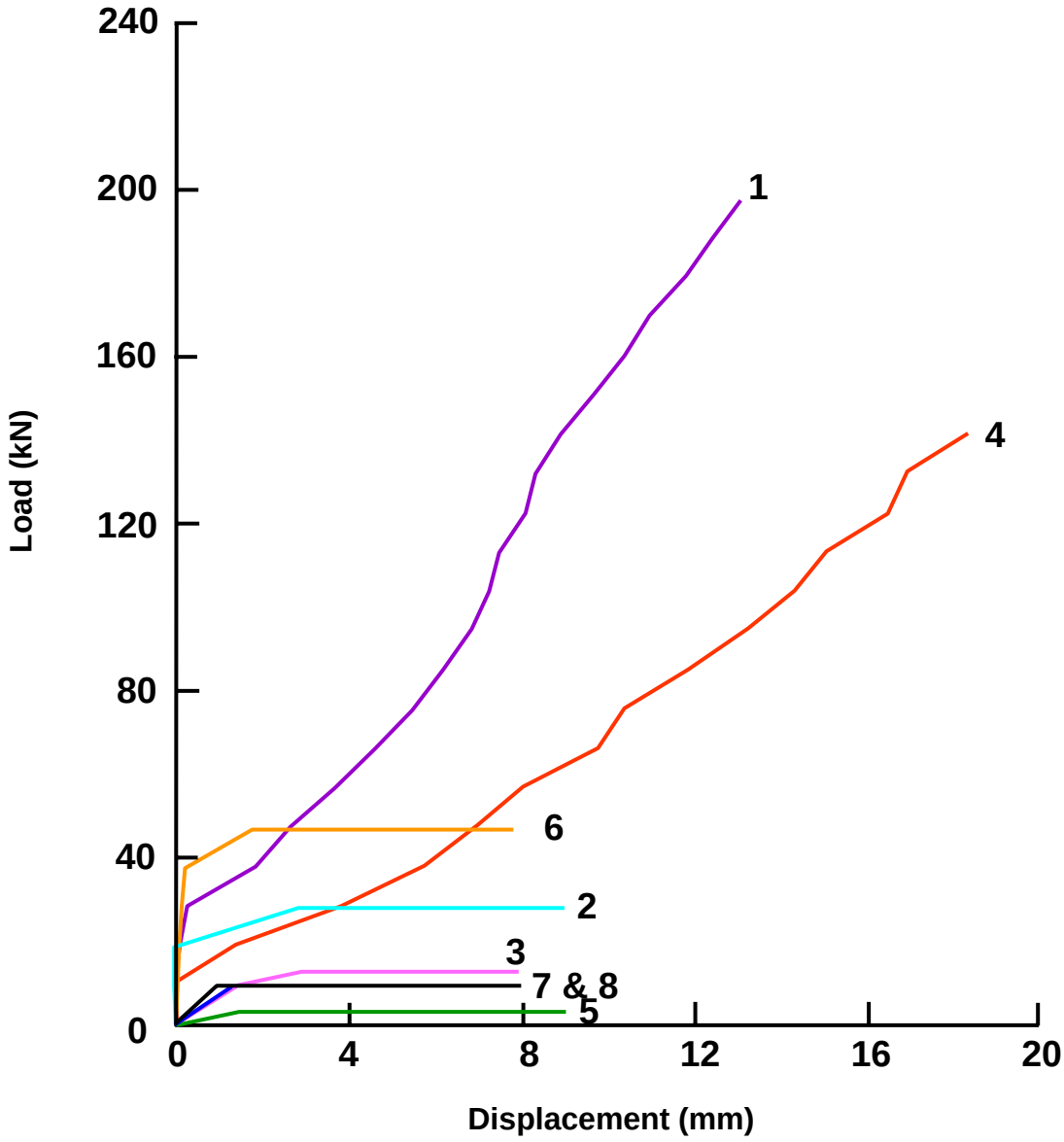
FIGURE 5.1
BCCOL704.ppt

LEGEND

1. South African Cable Anchor – Bulbed plain strand in Fasloc resin
2. South African Cable Anchor – Notched strand in Fasloc resin
3. South African Cable Anchor – Plain strand in Fasloc resin
4. South African Cable Anchor – Bulbed plain strand in Fasloc resin
5. South African Cable Anchor – Plain strand in Fasloc resin
6. South African Cable Anchor – Notched strand in Fasloc resin
7. South African Cable Anchor – Notched strand in SA grout
8. South African Cable Anchor – Plain strand in SA grout



LABORATORY SHORT ENCAPSULATION PULL TEST RESULTS FOR SOUTH AFRICAN CABLE ANCHOR SYSTEM TESTED IN CONFINED HOLLINGTON SANDSTONE (CONFINEMENT 10MPa / EMBEDMENT 250mm).

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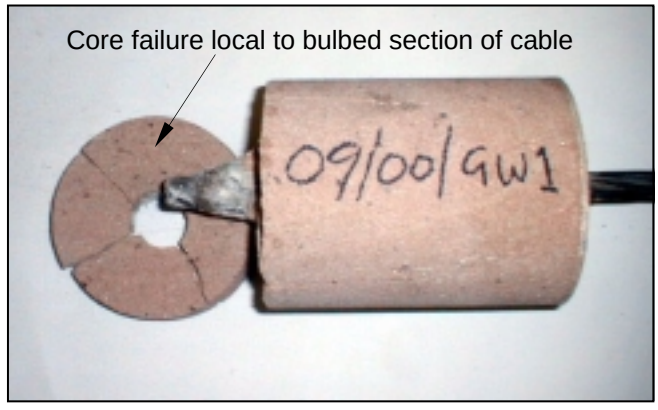
FIGURE 5.2
BCCOL704.ppt



BULBED PLAIN STRAND IN FASLOC RESIN (TEST 1)

BULBED PLAIN STRAND IN FASLOC RESIN (TEST 4)

SAMPLES AFTER TESTING IN RESIN IN CONFINED HOLLINGTON SANDSTONE USING THE LSEPT METHOD

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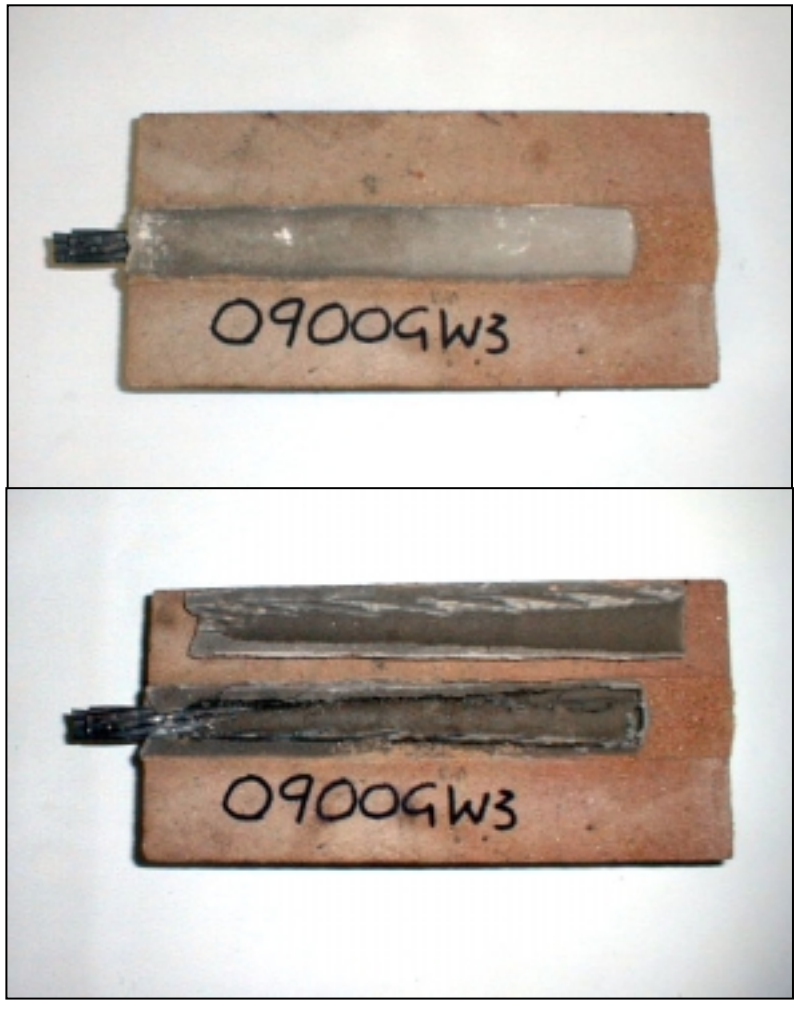
FIGURE 5.3
BCCOL704.ppt



UNBULBED PLAIN STRAND IN FASLOC RESIN (TEST 3)

UNBULBED PLAIN STRAND IN FASLOC RESIN (TEST 5)

SAMPLES AFTER TESTING IN RESIN IN CONFINED HOLLINGTON SANDSTONE USING THE LSEPT METHOD

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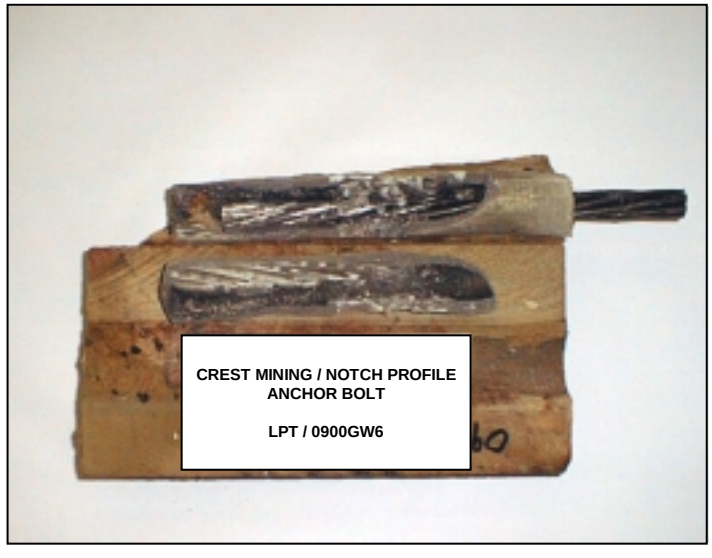
FIGURE 5.4
BCCOL704.ppt

UNBULBED NOTCHED STRAND IN FASLOC RESIN (TEST 2)



UNBULBED NOTCHED STRAND IN FASLOC RESIN (TEST 6)

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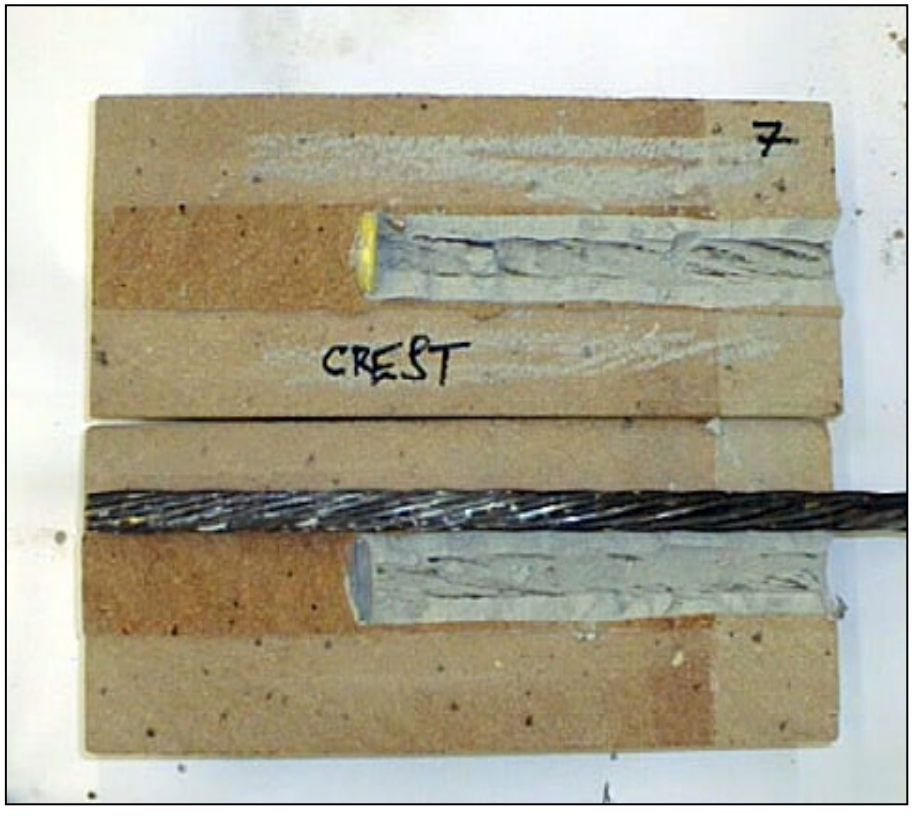
SAMPLES AFTER TESTING IN RESIN IN CONFINED HOLLINGTON SANDSTONE USING THE LSEPT METHOD

FIGURE 5.5
BCCOL704.ppt



UNBULBED NOTCHED STRAND IN SOUTH AFRICAN CABLE ANCHOR GROUT (TEST 7)

SAMPLE AFTER TESTING IN GROUT IN CONFINED HOLLINGTON SANDSTONE USING THE LSEPT METHOD

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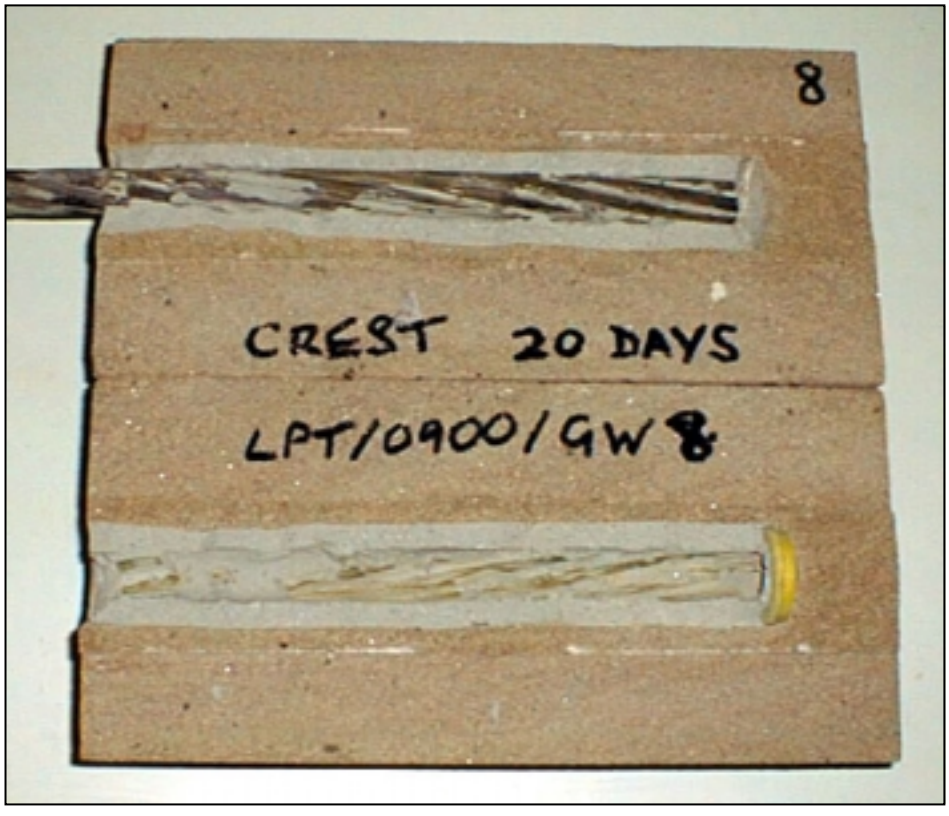
FIGURE 5.6
BCCOL704.ppt



UNBULBED PLAIN STRAND IN SOUTH AFRICAN CABLE ANCHOR GROUT (TEST 8)

SAMPLE AFTER TESTING IN GROUT IN CONFINED HOLLINGTON SANDSTONE USING THE LSEPT METHOD

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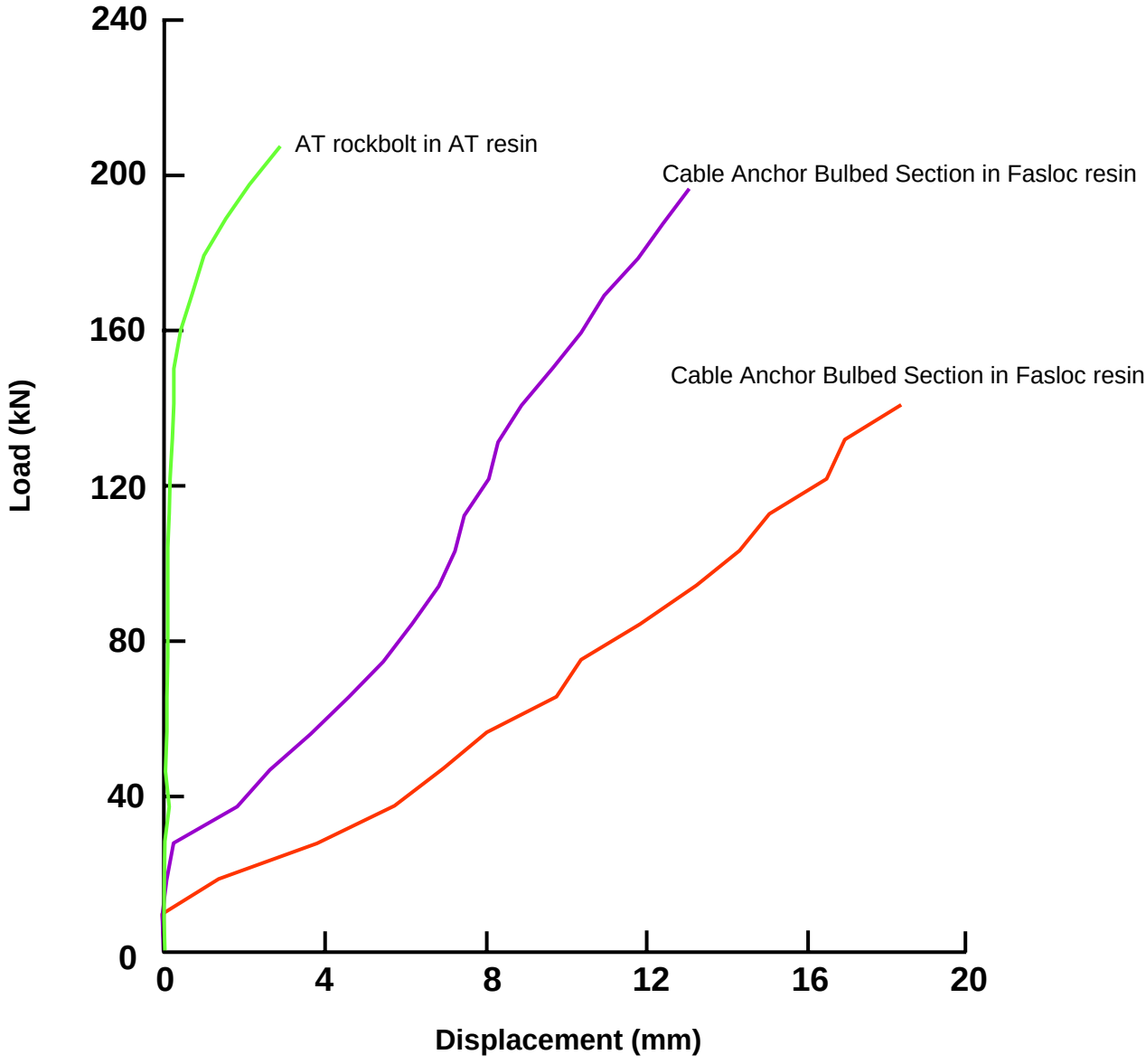
FIGURE 5.7
BCCOL704.ppt



COMPARISON OF THE PERFORMANCE OF THE BULBED CABLE ANCHOR INSTALLED IN FASLOC RESIN IN A 38mm DIAMETER HOLE WITH AT ROCKBOLT INSTALLED IN AT RESIN IN A 28.5mm DIAMETER HOLE. (BOTH USED ROCK CONFINEMENT OF 10MPa AND EMBEDMENT LENGTH OF 250mm)

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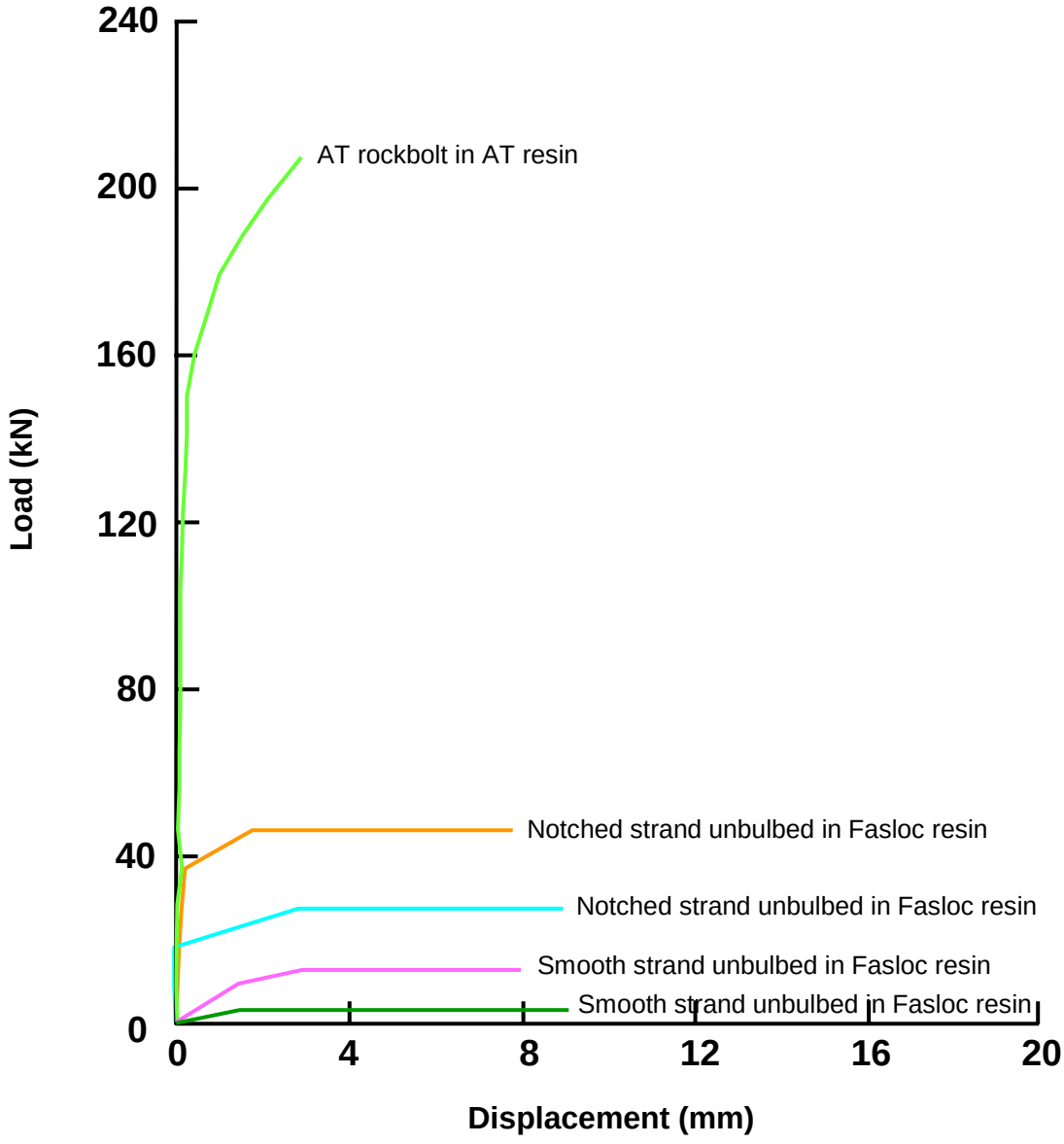
FIGURE 5.8
BCCOL704.ppt



COMPARISON OF PERFORMANCE OF UNBULBED SMOOTH AND NOTCHED STRAND CABLE ANCHOR INSTALLED IN FASLOC RESIN IN 38mm DIAMETER HOLE WITH
UK AT ROCKBOLT INSTALLED IN AT RESIN IN A 28.5mm DIAMETER HOLE.
(CONFINEMENT 10MPa / EMBEDMENT 250mm)

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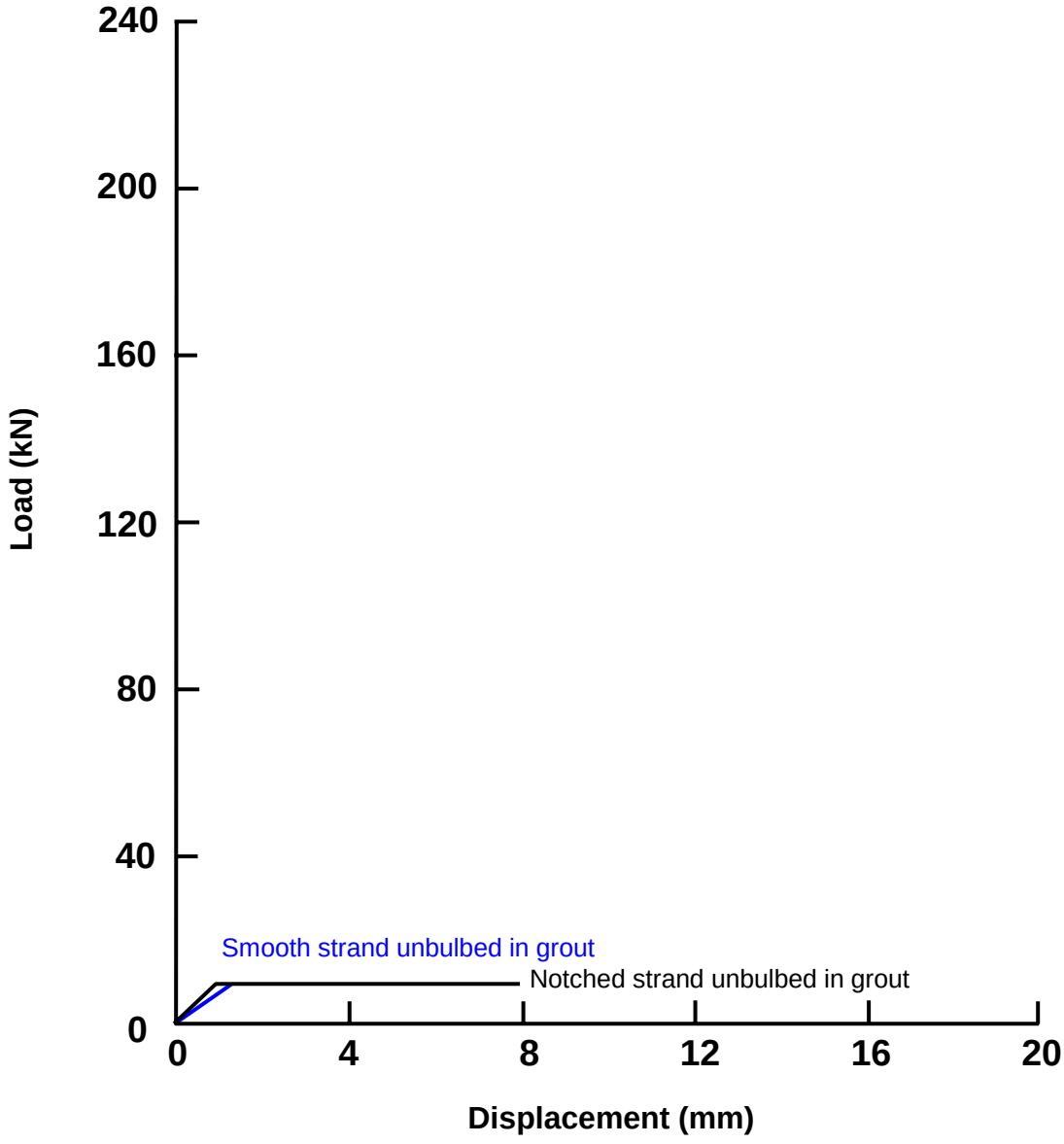
FIGURE 5.9
BCCOL704.ppt



COMPARISON OF PERFORMANCE OF SMOOTH AND NOTCHED UNBULBED CABLE ANCHOR INSTALLED IN FASLOC RESIN IN 38mm DIAMETER HOLE (CONFINEMENT 10MPa / EMBEDMNET 250mm)

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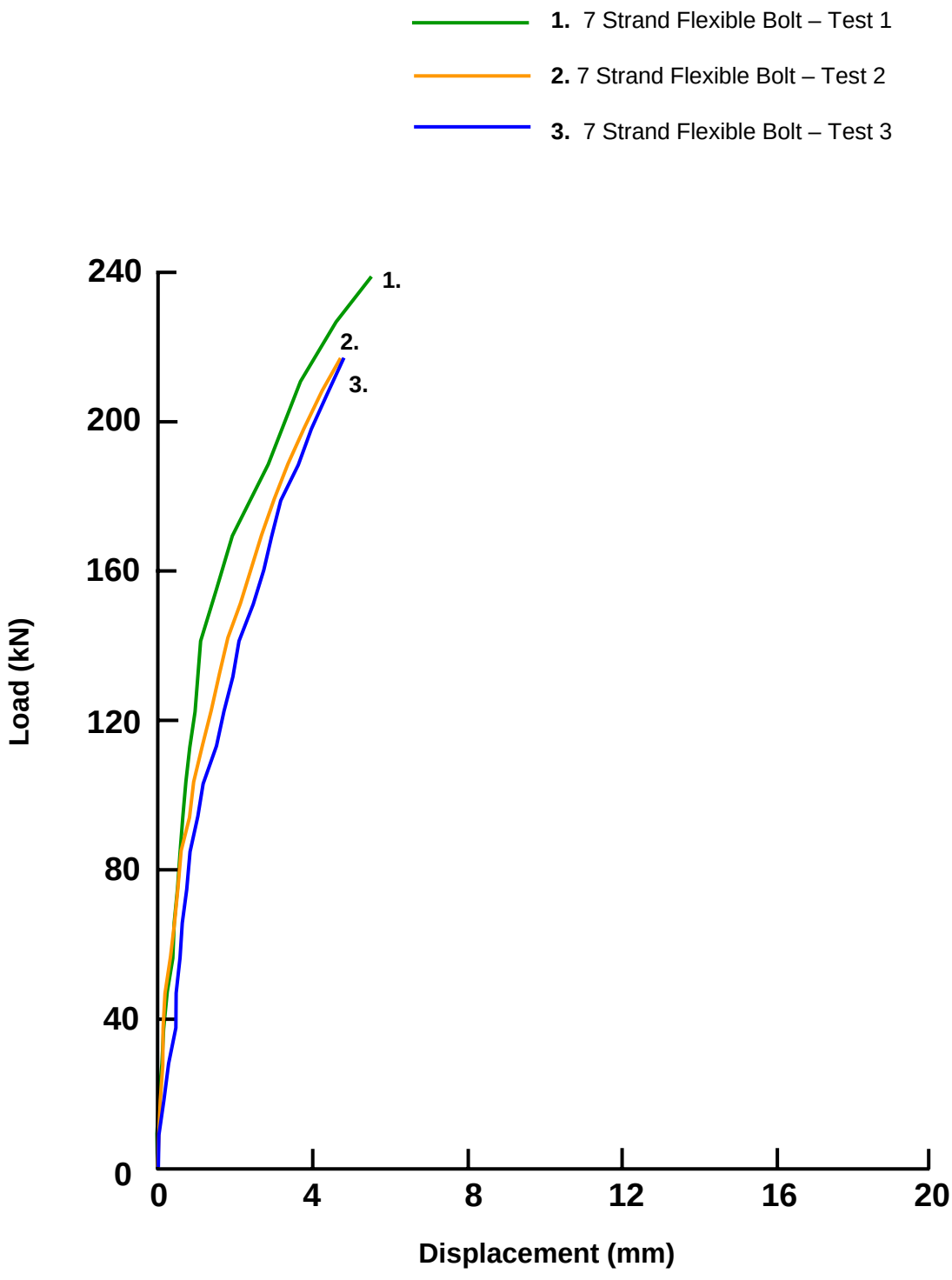
FIGURE 5.10
BCCOL704.ppt



LABORATORY SHORT ENCAPSULATION PULL TEST RESULTS FOR UK FLEXIBLE BOLT SYSTEM TESTED IN CONFINED HOLLINGTON SANDSTONE (CONFINEMENT 10MPa / EMBEDMENT 250mm)

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FIGURE 5.11
BCCOL704.ppt

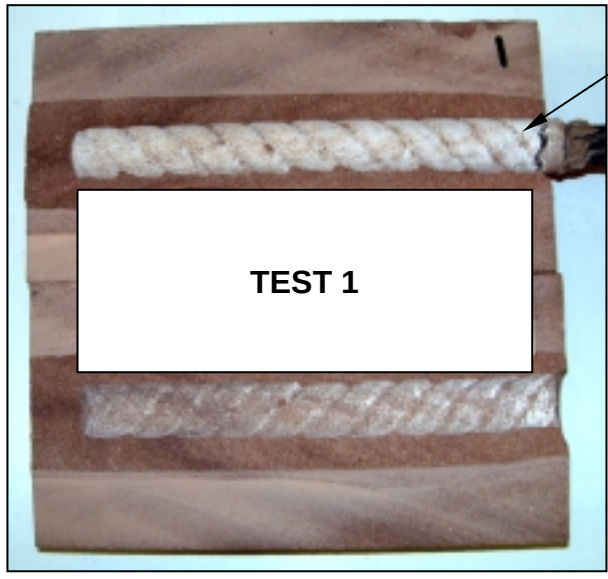

FIGURE 5.12

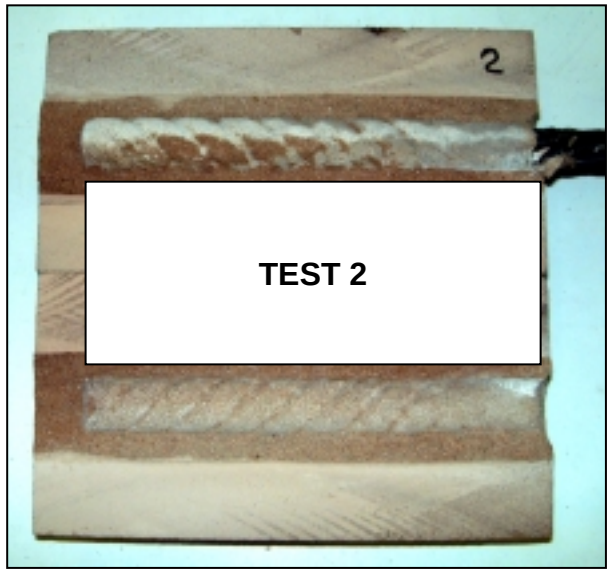

FIGURE 5.13

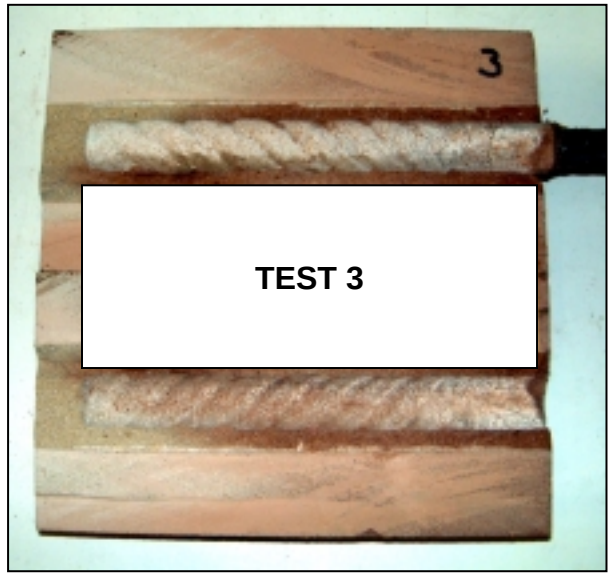

FIGURE 5.14

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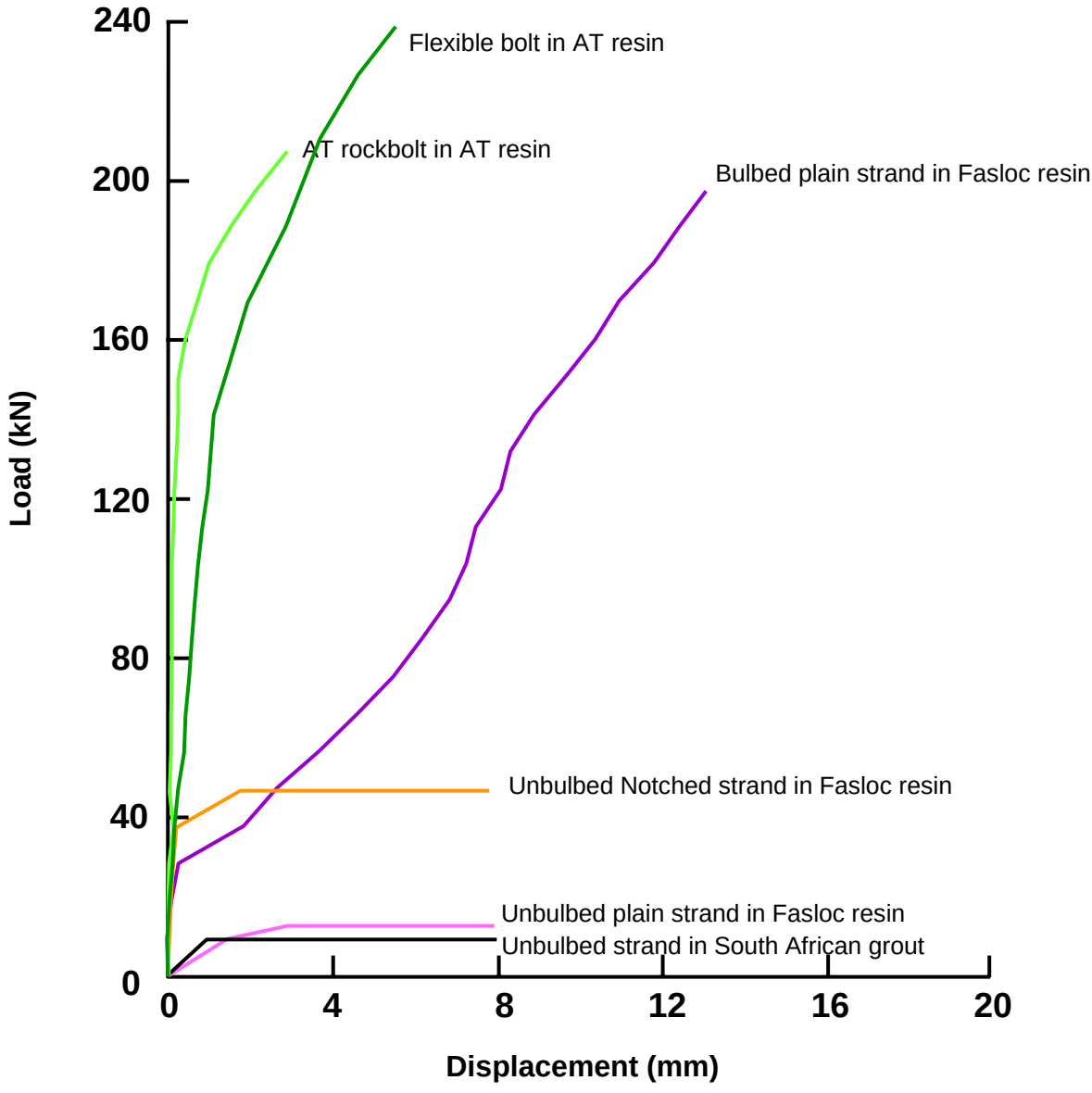
LABORATORY SHORT ENCAPSULATION PULL TESTS IN HOLLINGTON SANDSTONE – FLEXIBLE BOLTS AND AT RESIN



PERFORMANCE COMPARISON FOR CABLEBOLT SYSTEMS BASED ON LABORATORY SHORT ENCAPSULATION PULL TESTS

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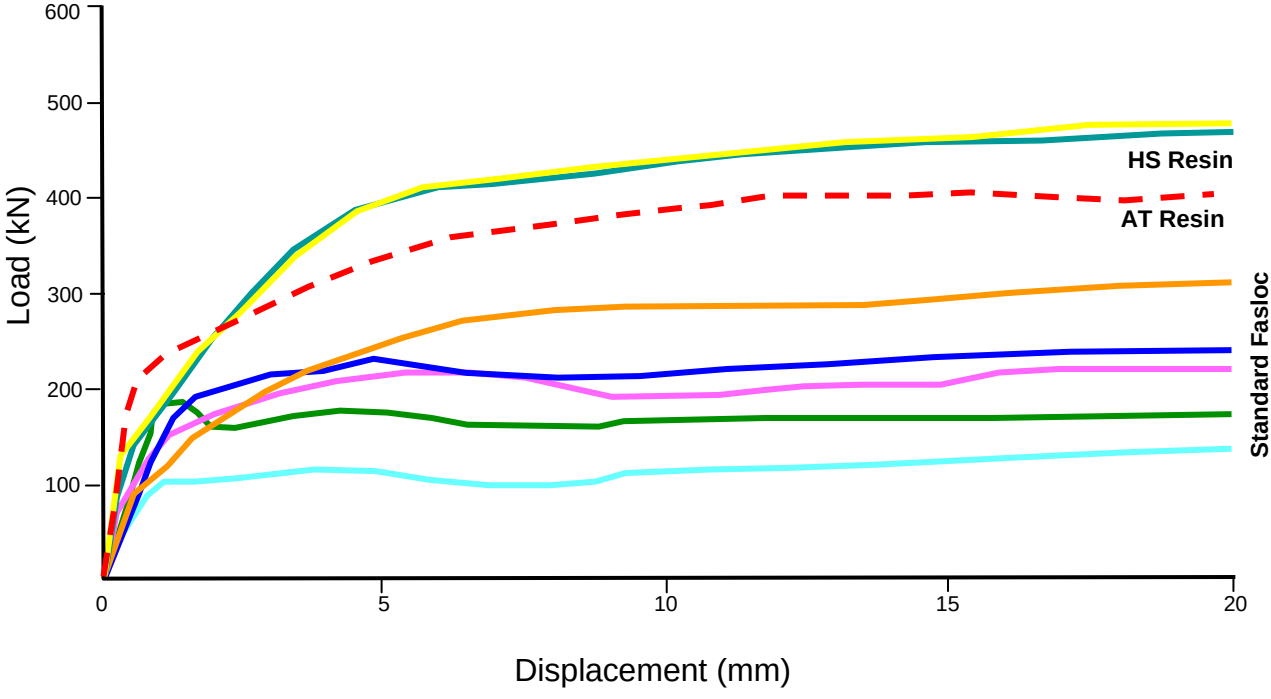
FIGURE 5.15
BCCOL704.ppt



DOUBLE EMBEDMENT TESTS ON FLEXIBLE BOLTS IN SOUTH AFRICAN RESINS (450mm EMBEDMENT)

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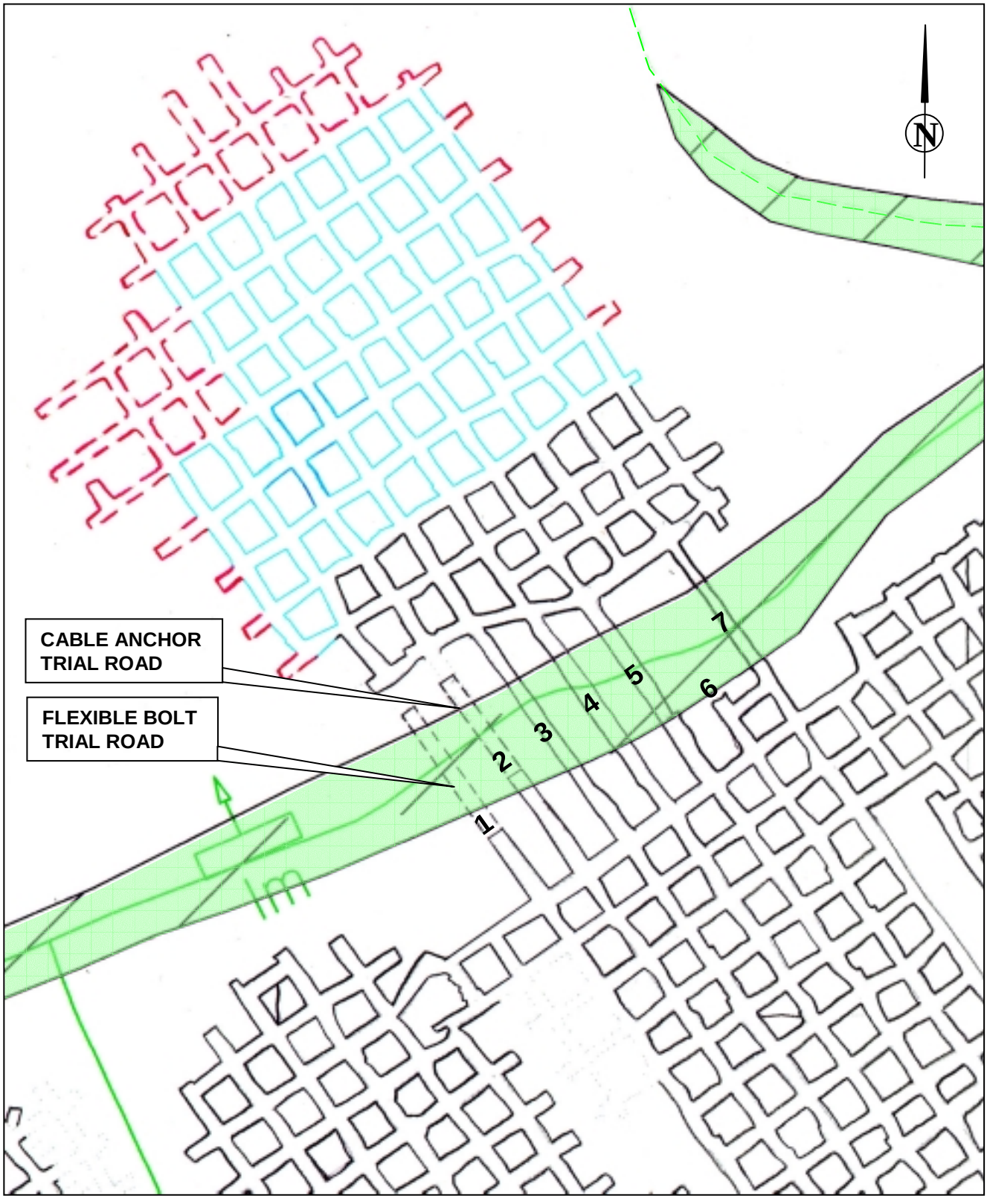
FIGURE 5.16
BCCOL704.ppt

CHAPTER 6



TWISTDRAAI CENTRAL COLLIERY
4 SEAM- SECTION 71
FLEXIBLE BOLT TRIAL SITE

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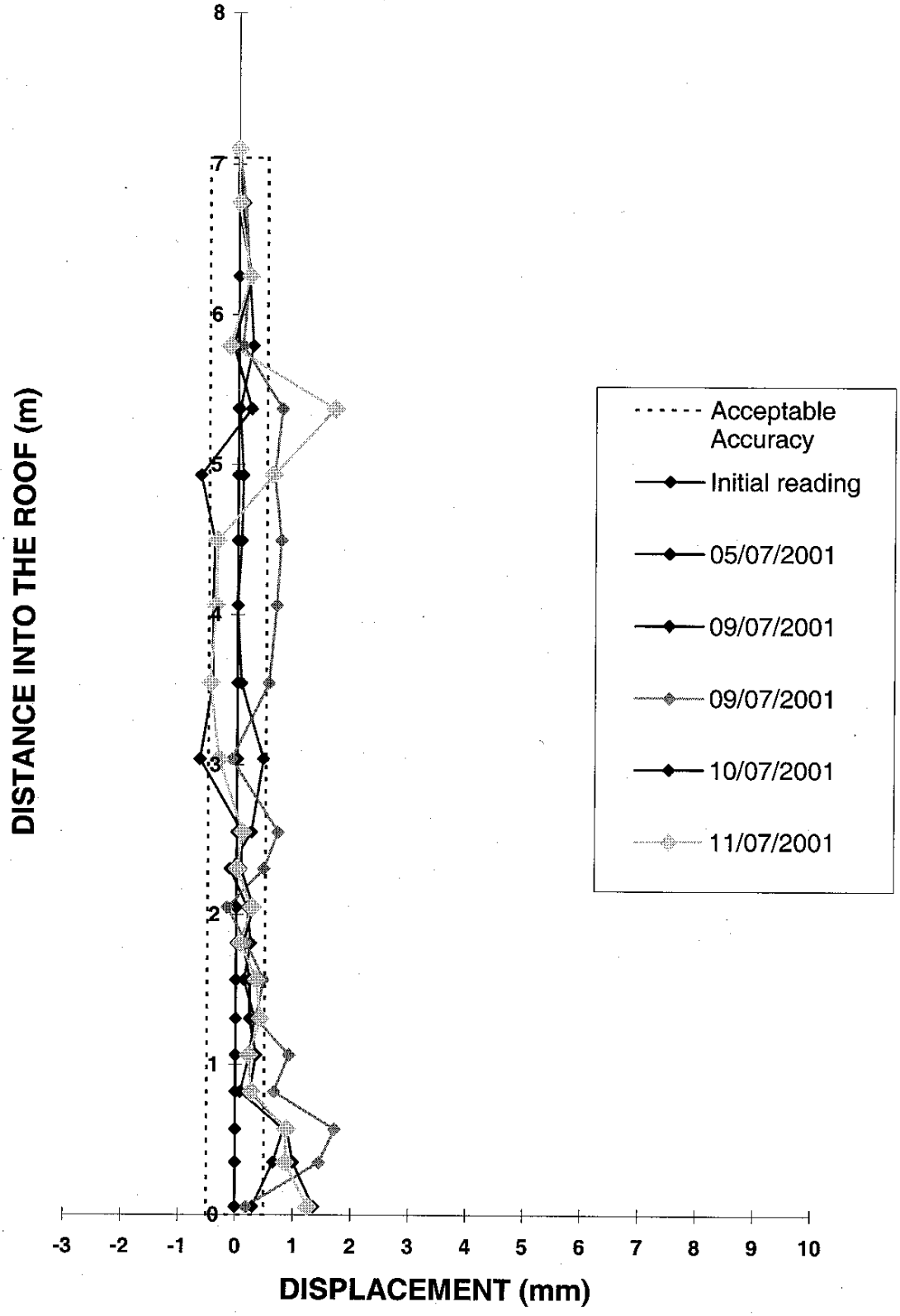
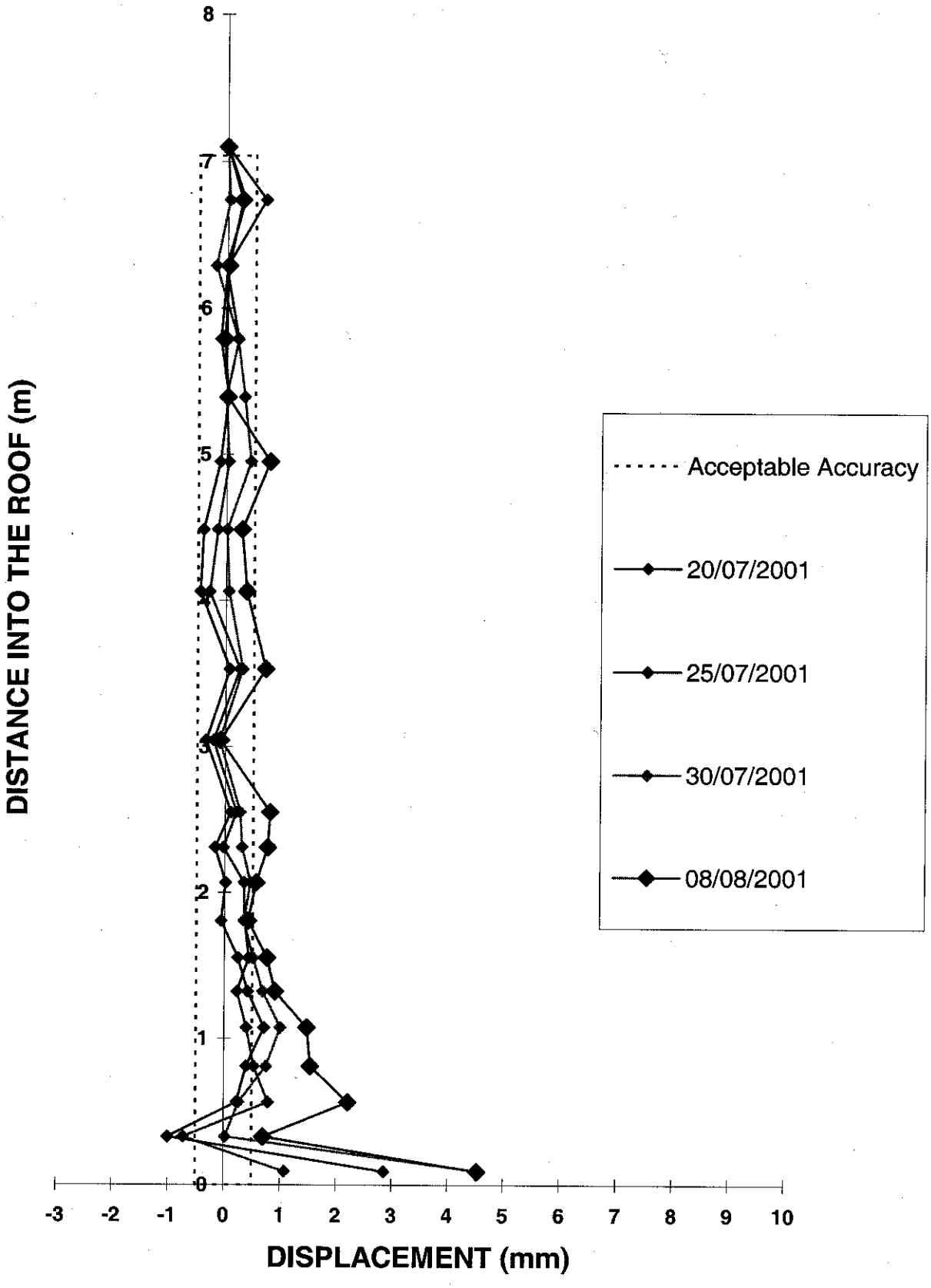
FIGURE 6.4
BCCOL704.ppt



TWISTDRAAI ROADWAY No.1
SONIC EXTO No.1

RMT
Rock Mechanics Technology

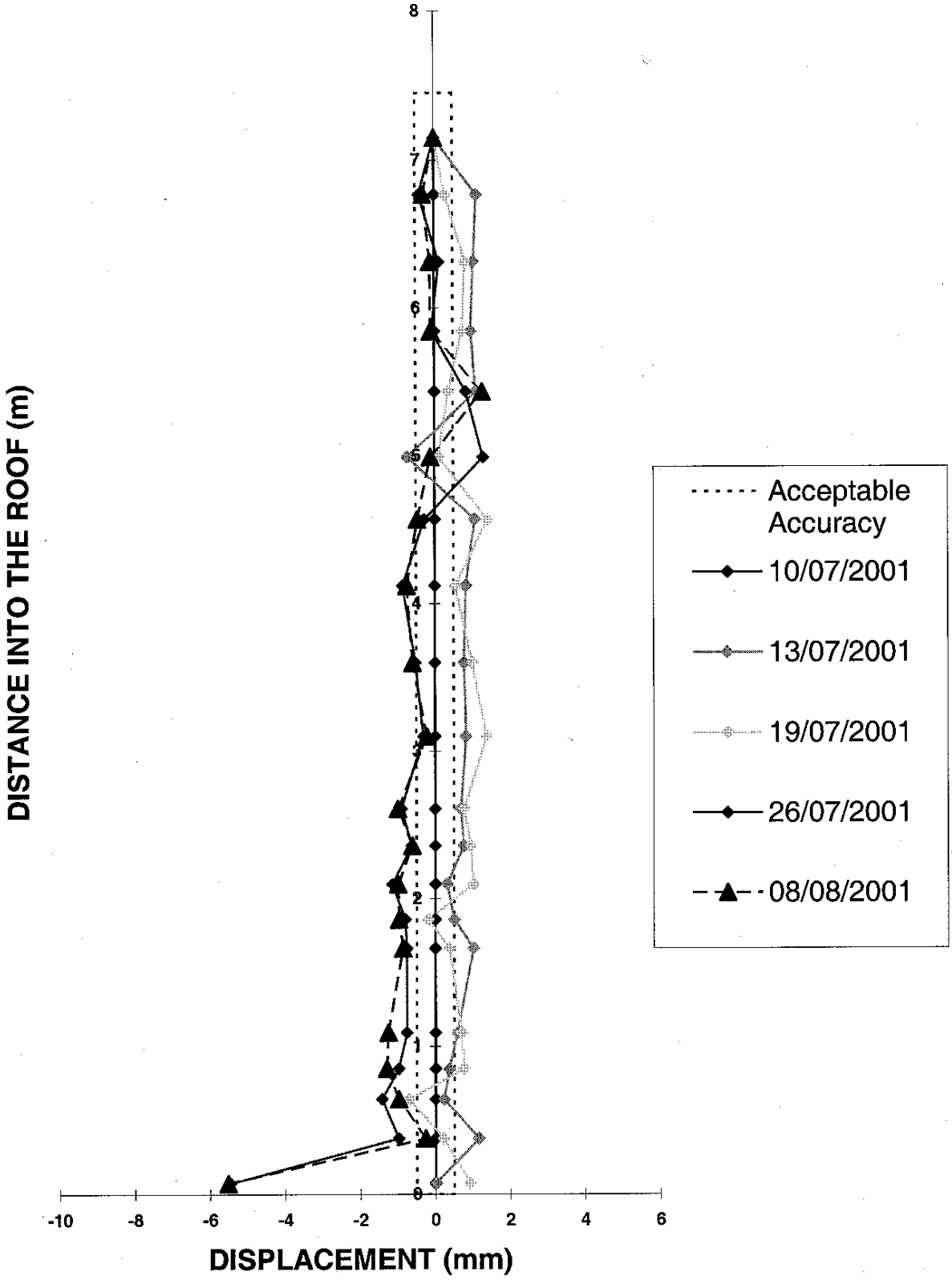
FIGURE 6.13
BCCOL704.ppt



TWISTDRAAI ROADWAY No.1
SONIC EXTO No.2

RMT
Rock Mechanics Technology

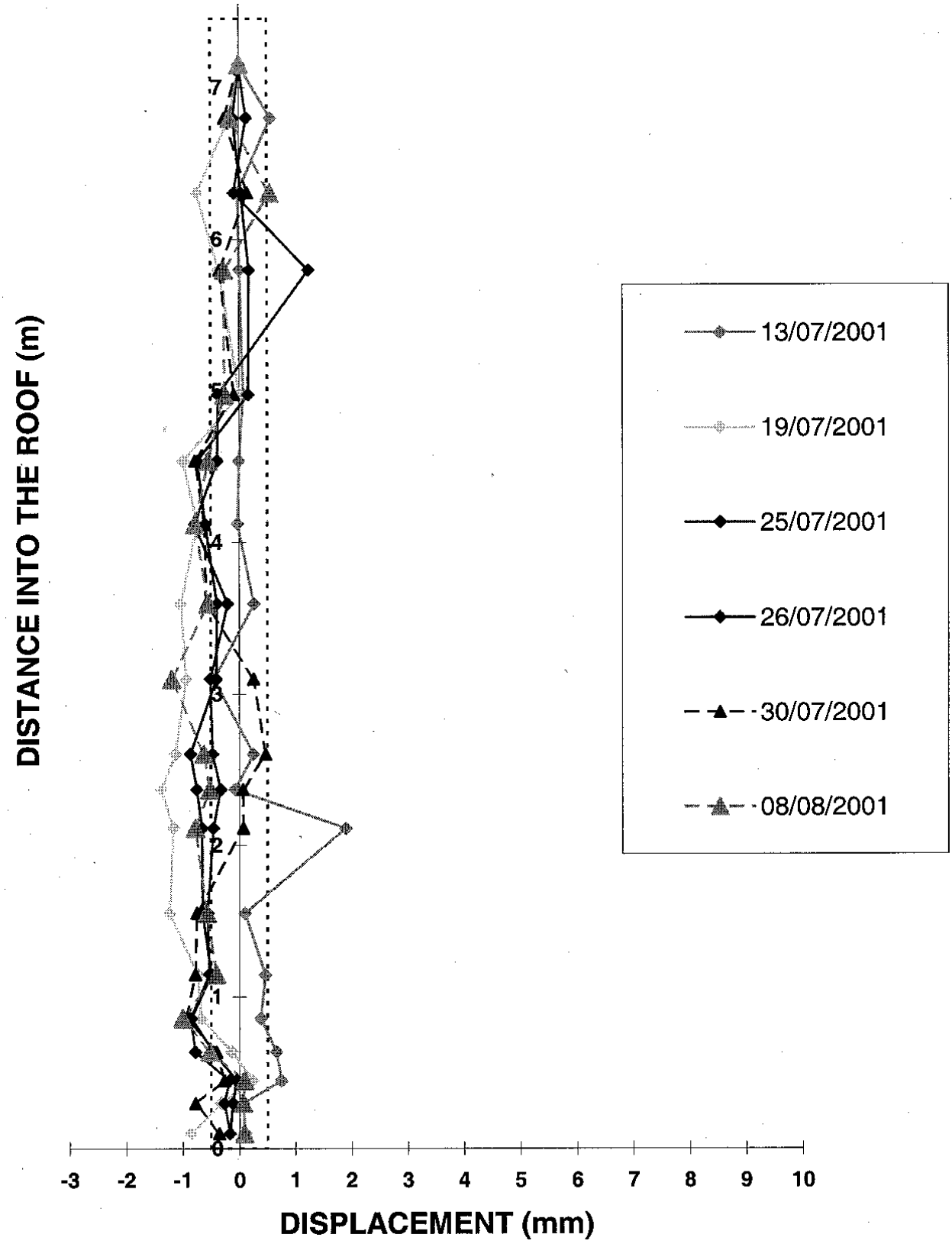
FIGURE 6.14
BCCOL704.ppt



TWISTDRAAI ROADWAY No.2
SONIC EXTO No.3

RMT
Rock Mechanics Technology

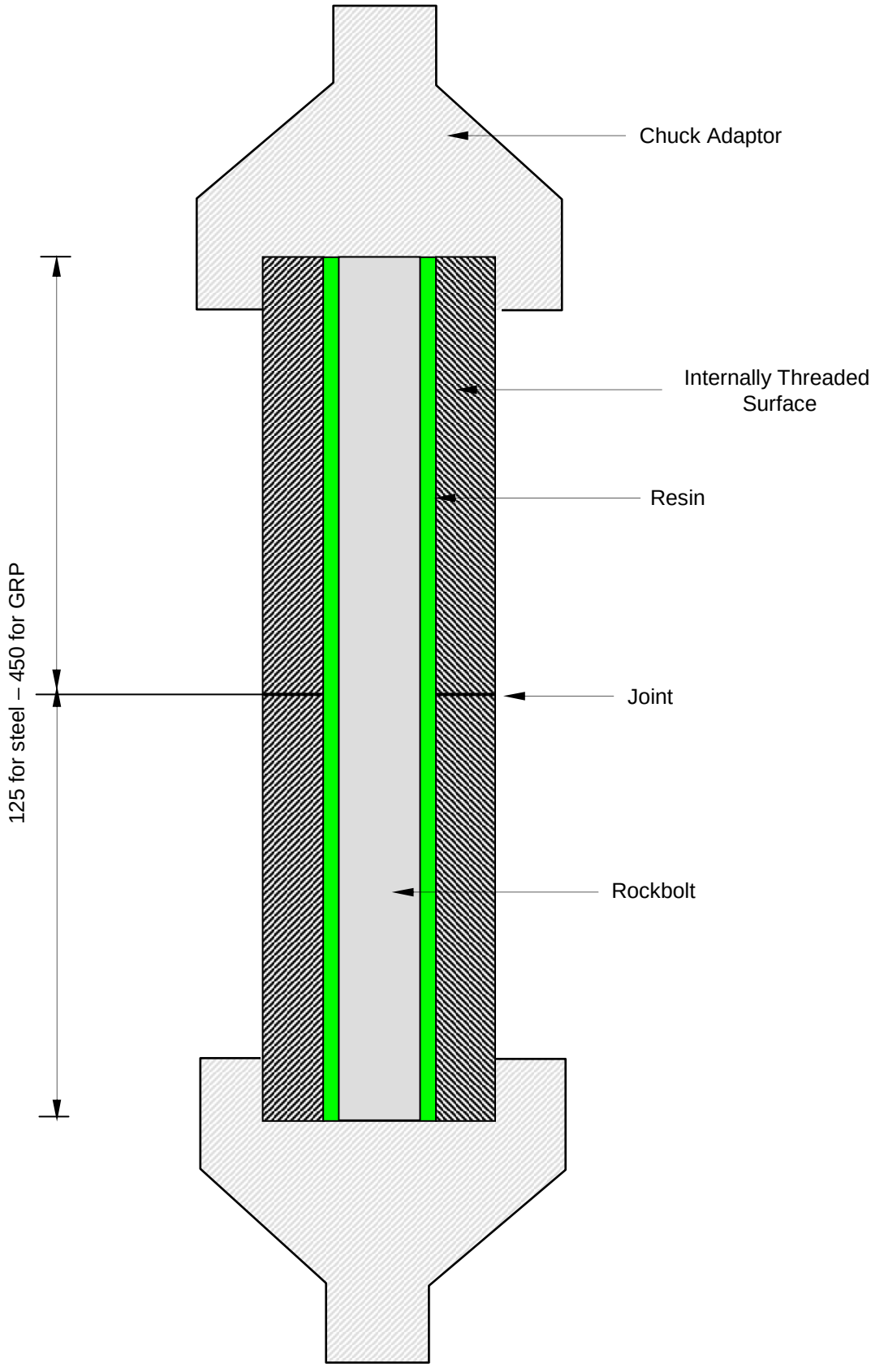
FIGURE 6.15
BCCOL704.ppt



TWISTDRAAI ROADWAY No.2
SONIC EXTO No.4

RMT
Rock Mechanics Technology

FIGURE 6.16
BCCOL704.ppt



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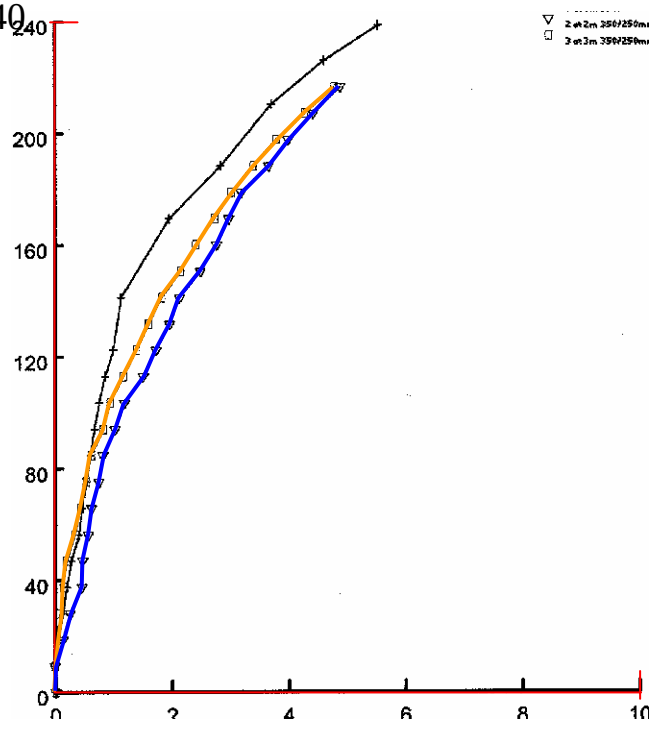
ARRANGEMENT FOR DOUBLE EMBEDMENT PULL TEST

FIGURE A 3.1

BCCOL704.ppt

240



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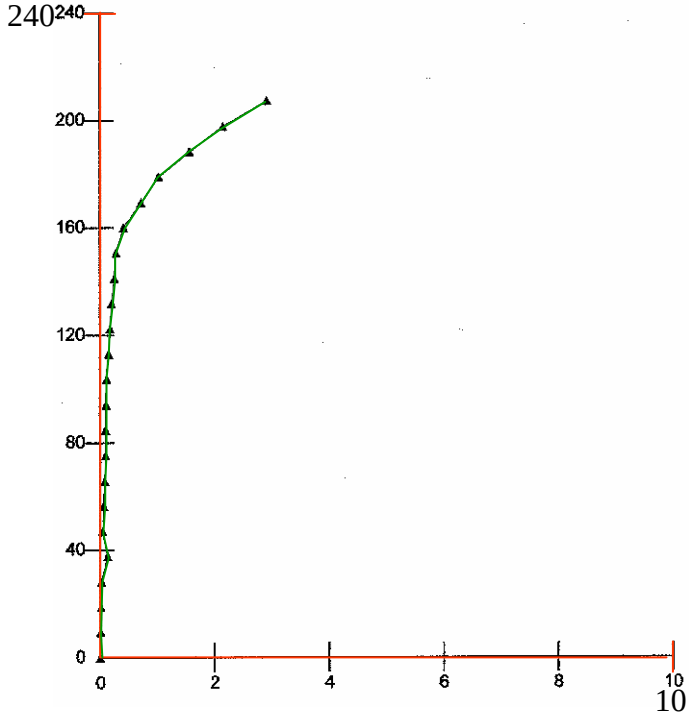
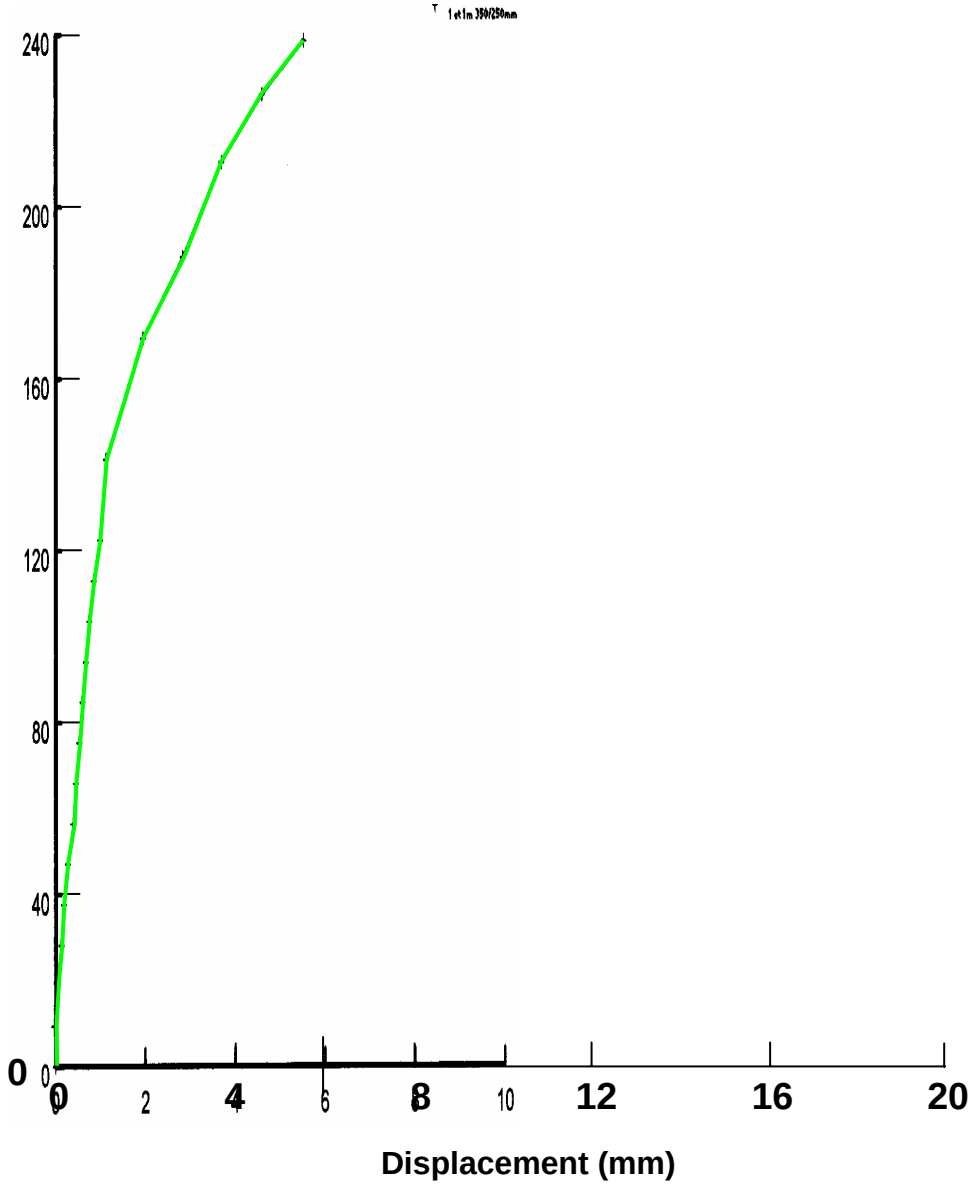
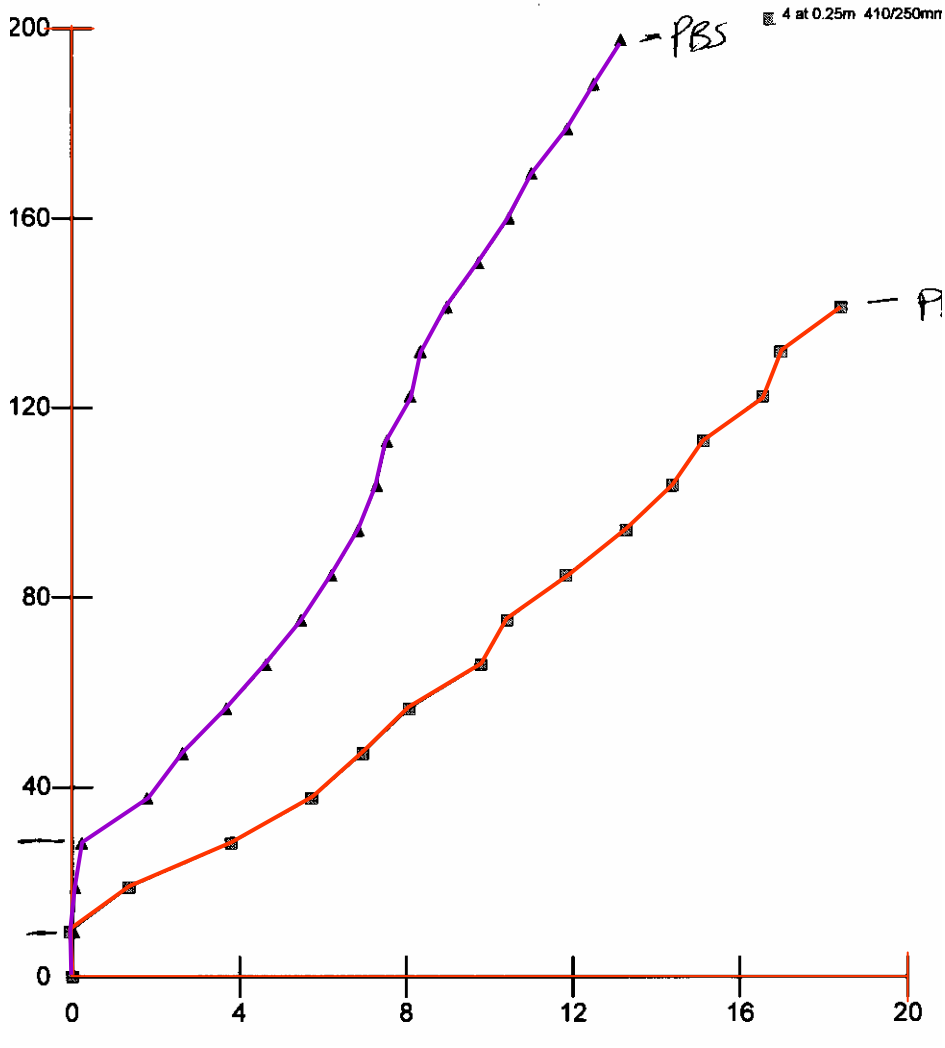
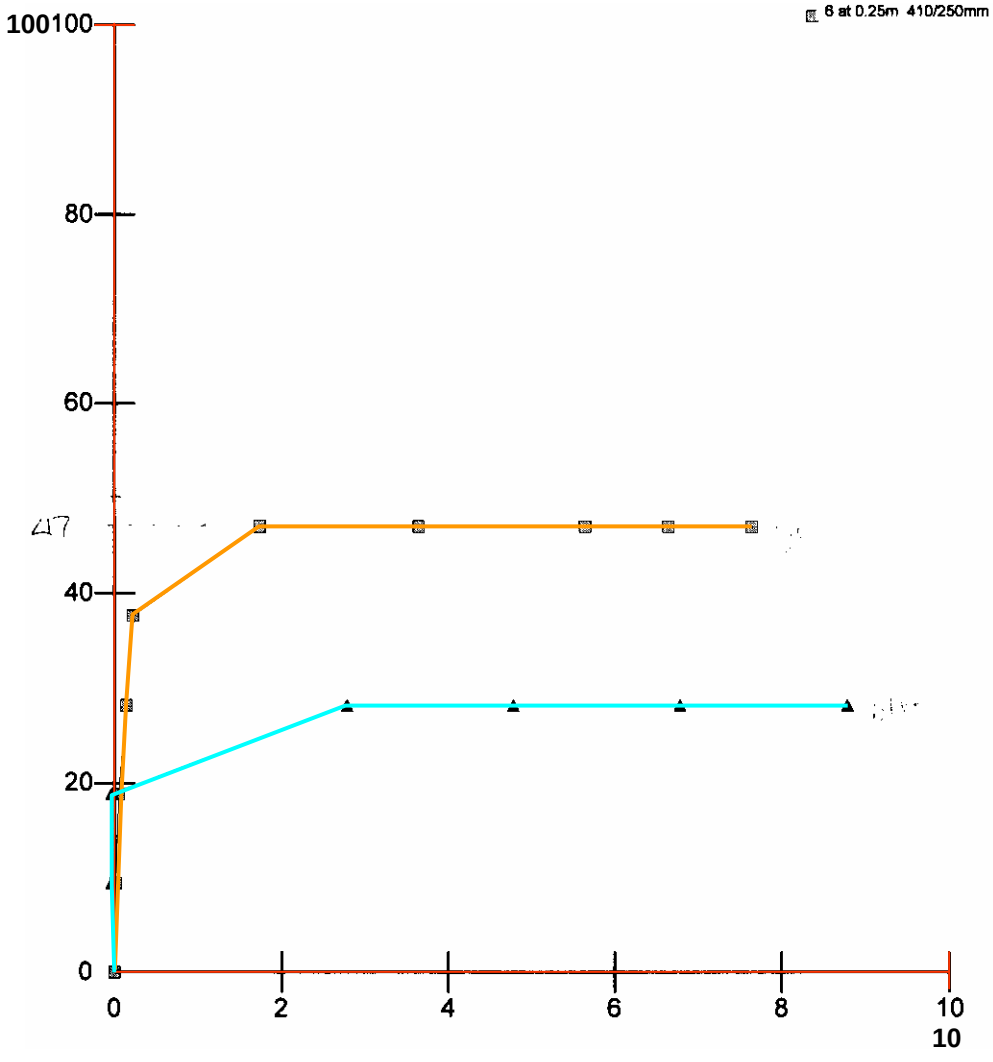
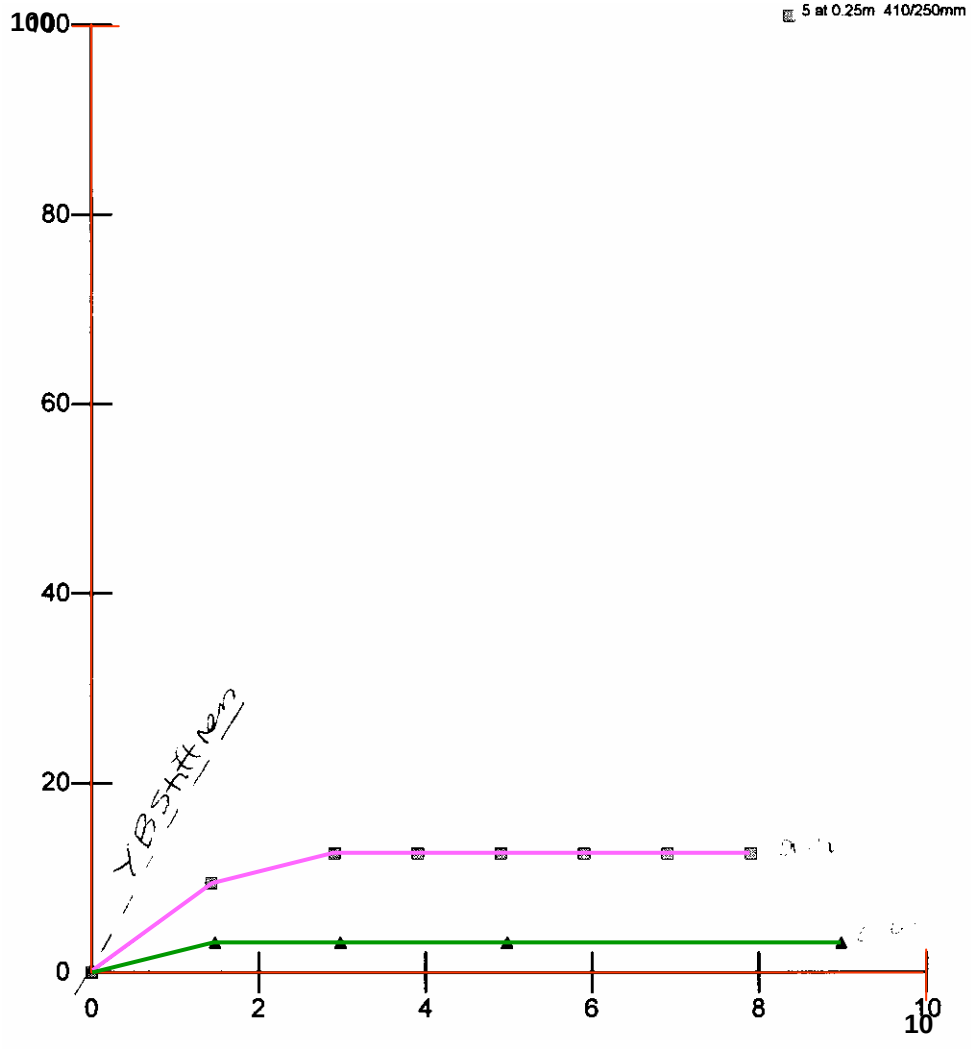
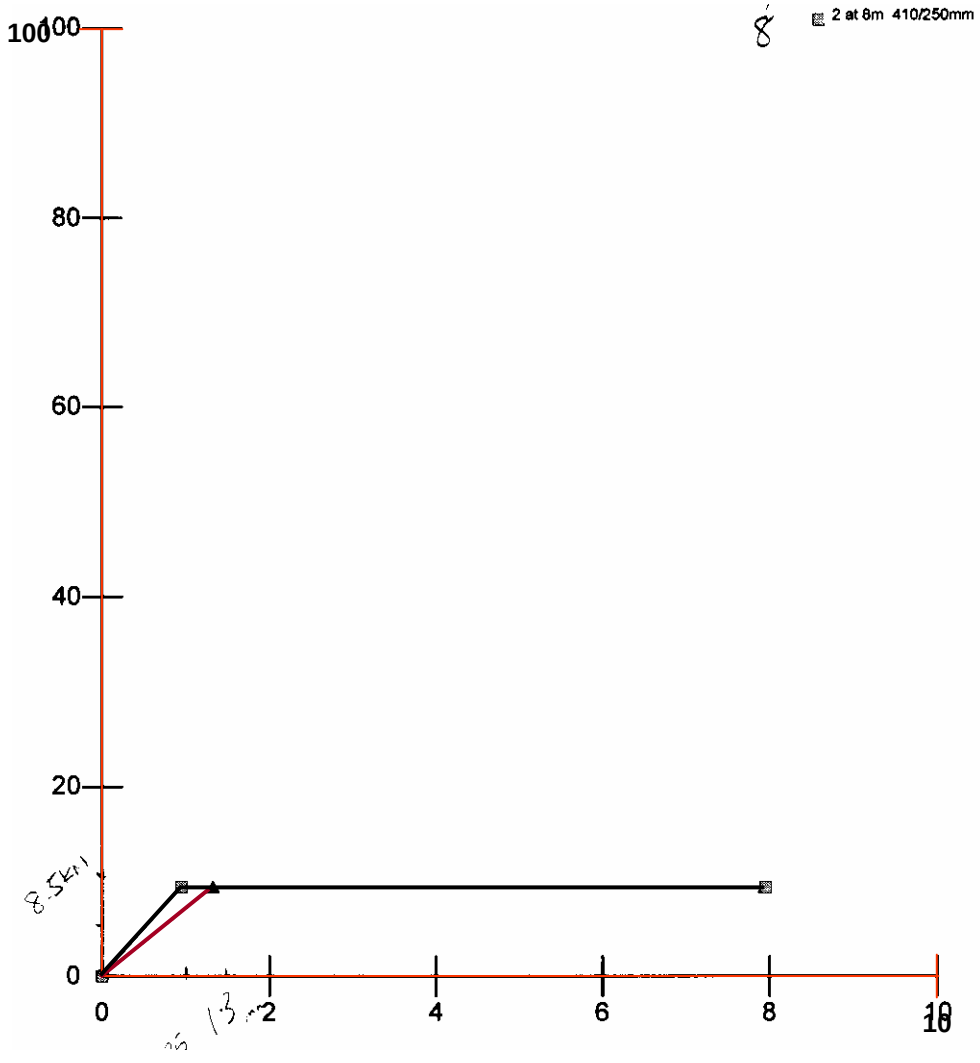

240
240
200
160
120
80
40
0
0
2
4
6
8
10
10


240
200
160
120
80
40
0
0
0
2
4
6
8
10
12
16
20
Displacement (mm)


4 at 0.25m 410/250mm
PBS
200
160
120
80
40
0
0
4
8
12
16
20


6 at 0.25m 410/250mm
100100
80
60
40
20
0
0
2
4
6
8
10
10


5 at 0.25m 410/250mm
1000
80
60
40
20
0
0
2
4
6
8
10
10


2 at 8m 410/250mm
100
80
60
40
20
0
0
2
4
6
8
10