Impala Platinum Limited
Rock Engineering

Lessons Learned in Decline Support Design at Impala Platinum Mine

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September 2000

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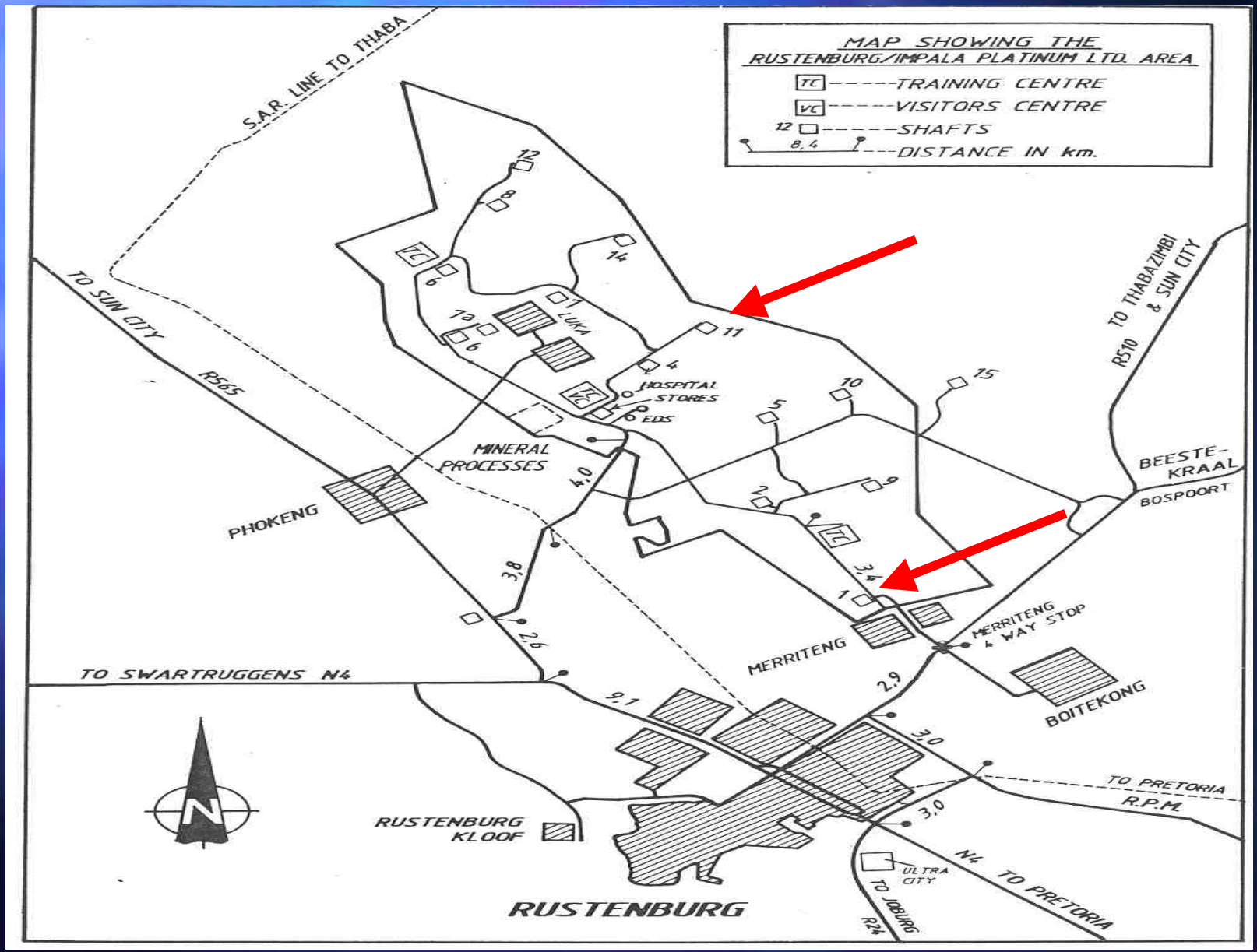
Locality Plan



Geological Setting

Average Thickness (m)	Unit	Rock Type
34	HW5	Mottled and spotted Anorthosite
3-6	HW4	Spotted Anorthosite (SA)
5-7	HW3	Mottled Anorthosite (MA)
1,5-3	HW2	Spotted Anorthositic Norite
2-6	HW1	Norite
2-3	Bastard Pyroxenite	Pyroxenite, Coarse Grained
2-3	M3	Mottled Anorthosite
3-7	M2	Spotted Anorthositic Norite
0,5	M1	Norite
1-1,5	Merensky Pyroxenite	Medium to Coarse grain Pyroxenite
	Merensky Reef	Chromitite Layer - Pegmatoid
0,4	FW1	Spotted Anorthositic Norite (SAN)
0,2	FW2	Cyclic Unit (Pyroxenite-SAN-MA)
3-5	FW3	Spotted Anorthositic Norite
0,1-0,3	FW4	Mottled Anorthosite
1-3	FW5	Spotted Anorthositic Norite
1-3	FW6	Cyclic Unit (MA-SA-MA)
1-3	FW7	Spotted Anorthositic Norite
0,8-1,2	FW8	Spotted Anorthosite
3-6	FW9	Mottled Anorthosite
3-5	FW10	Spotted Anorthositic Norite
12-15	FW11	Spotted Anorthosite
10-12	FW12	Mottled Anorthosite
5-7		UG2 Pyroxenite with Leader Chromitite Stringers
0,7	UG2 Reef	Chromitite
10-12	FW	UG2 Pegmatoid
5-7	FW13	Spotted Anorthositic Norite

Support Design Methodology

From Barton et al :

$$L = \frac{2 + 0.15 * B}{ESR}$$

Where:
L is bolt length;
B is the excavation width;
ESR is the Excavation Support Ratio - a value related to the intended use of the excavation and the degree of security, which is demanded of the system - For permanent mine openings the ESR = 1.6.

Support Design Methodology

- 4m Wide Excavation (Chairlift) :

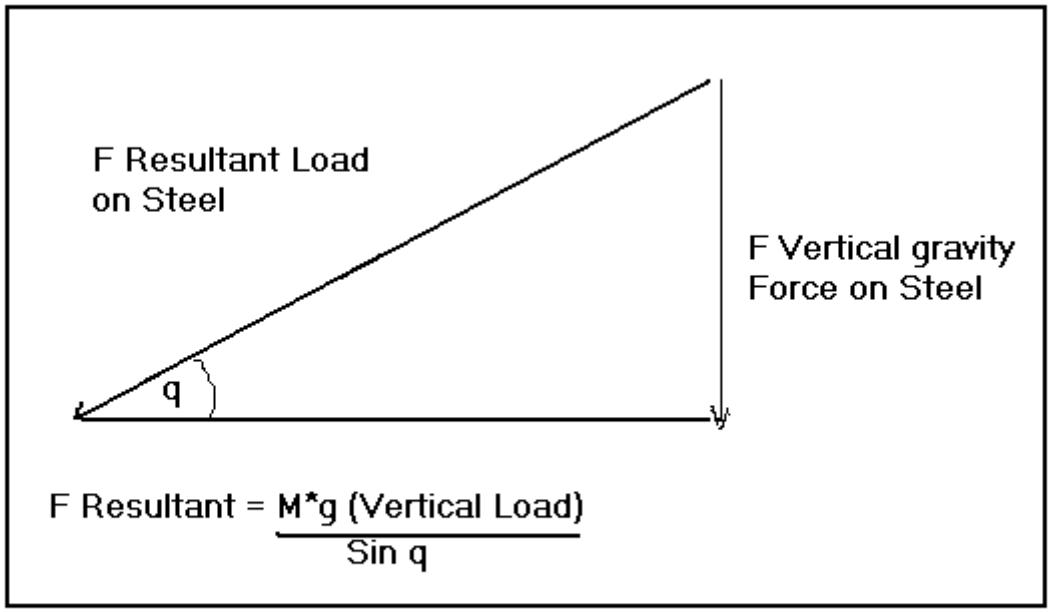
1. L (height to support) = 1,63m
2. Yielding Load Required = 76,6 kN (1,5 FOS)

- 5,6m Wide Excavation (Conveyor) :

1. L (height to support) = 1,8m
2. Yielding Load Required = 84,7 kN (1,5 FOS)

Support Design Methodology

Loading of Tendons at Angles :



Support Design Methodology

Loading of Tendons at Angles :

Angle of installation	Loading formulae for bolts	% Load reduction on steel	Additional calculation factor
90 °	$F_R=m*g$	0	1
60 °	$F_R=1,15*m*g$	13,4	1,15
45 °	$F_R=1,414*m*g$	29,3	1,42
30 °	$F_R=2*m*g$	50	2

Case Studies

1. No. 1-Shaft

2. No. 11-Shaft

Case Studies

1. No. 1-Shaft (Resin Bolting)

Critical Parameters :

- Angle of Installation
- Critical Bond Length for Resin Bolting

Case Studies

No. 1-Shaft (Resin Bolting)

1. Angle of Installation
   - 70 Deg.
   - Load Requirements :

- 4m Wide Excavation (Chairlift) :

  Yielding Load Required = 81,5 kN
  (1,5 FOS)

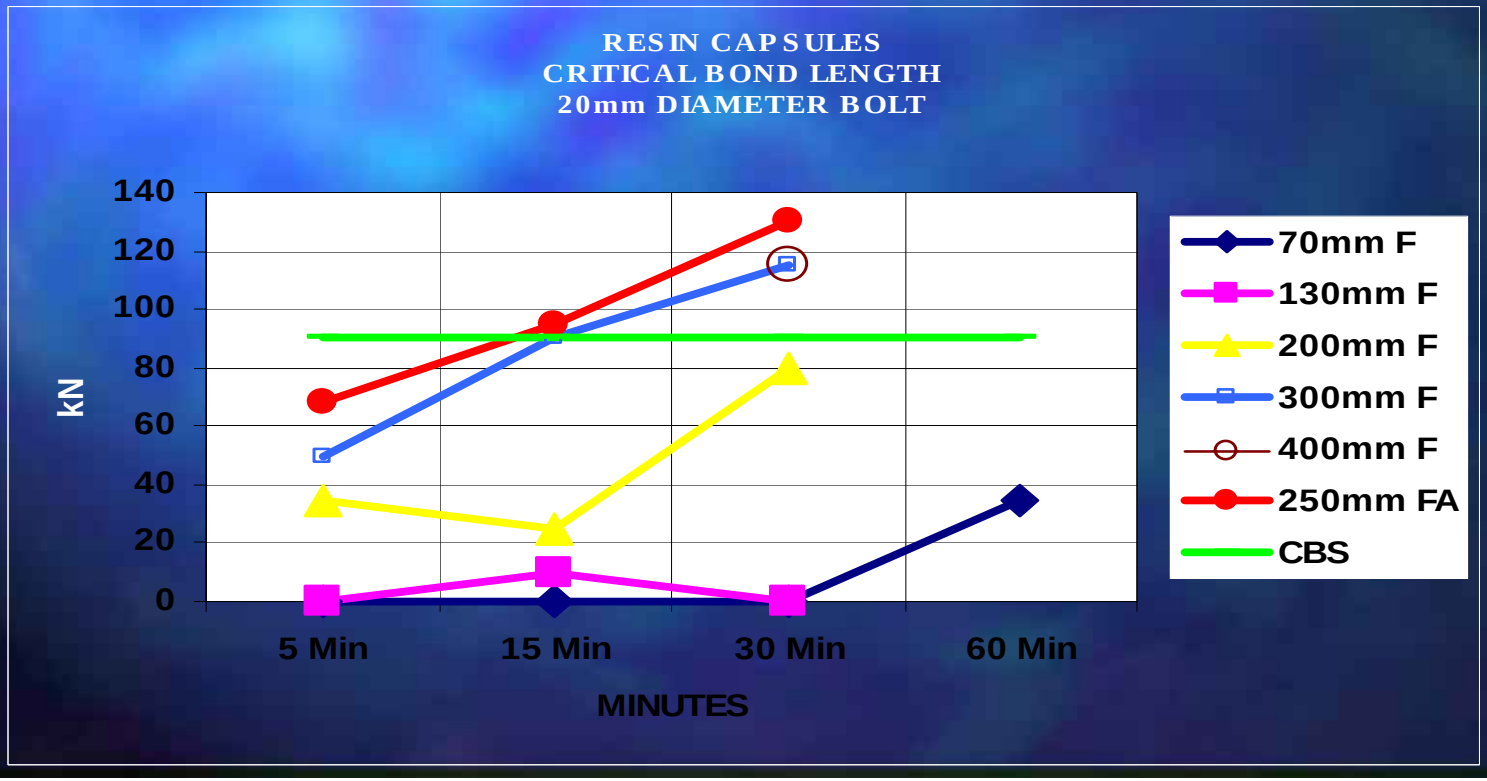
- 5,6m Wide Excavation (Conveyor) :

  Yielding Load Required = 90,1 kN
  (1,5 FOS)

Case Studies

No. 1-Shaft (Resin Bolting)

2. Critical Bond Length :



Case Studies

1. No. 11-Shaft (Split Sets)

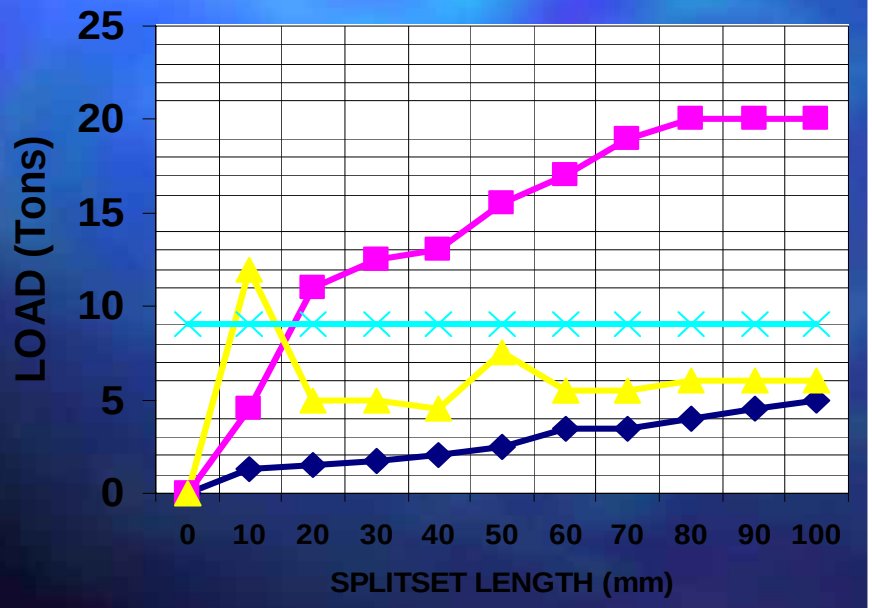
Critical Parameters :

- Critical Bond Length for Split Sets
- Corrosion

Case Studies

No. 11-Shaft (Split Sets)

1. Critical Bond Length for Split Sets :



- Ungrouted 44mm Dia. Hole
- Grouted 44mm diameter Hole
- Splitted Ring Ungrouted in 42mm Dia. Hole
- Critical Bond Strength

Case Studies

No. 11-Shaft (Split Sets)

2. Corrosion :

Hypothesis Testing for Split Set data :

1) <u>One Tailed Test</u>

H0 : There is no difference in the mean material loss of 2,4mm thick Split Set than of 3,2mm Split Set

H1 : The mean material loss of the 2,4mm Split Set underground is larger than the 3,2mm Split Set tested in the lab.

H0 : U = 0.1982

H1 : U ≠ 0.1982

Conclusions

Bolting at Angles

1. Gravity effects the bending moment acting on steel tendon

2. Bolt design should include reduction of steel strength when bolt is installed at angles less than 90 deg. to the vertical

Conclusions

Resin Bolting

1. Hole size must not be in excess of 8mm either side of bolt – 34mm hole ideal
2. Ultimate setting time – 15 min for critical bond length of 300mm
3. Storage life – 6 months @ 20 deg.

Conclusions

Split Sets as Permanent Support

1. Hole size is extremely critical to obtain required load from Split Sets
2. Frictional load does not increase significantly with an increase in Split Set length
3. Ring welded to end of Split Set contributes a large degree to higher loads obtained from full length Split Sets pull tests

Conclusions (cont)

Split Sets as Permanent Support

4. Grouting of the hole through the Split Set is critical to the final design load requirements

5. Critical bond length of grouted Split Set is 18cm for a 5,6m wide excavation

6. For life of mine hot rolled Galvanized Split Sets are required