

RESIN BOLT PROJECTILES

Hazard control, Rosebery Mine

March 2015

PROJECTILE FAILURE?





Projectile failure samples from lower mine



Typical projectile failure

PRESENTATION OVERVIEW



- The mine
- Projectile failures
- Hazard control methods
- MSR Development
- Current status
- Summary

ROSEBERY MINE





MINING METHOD





GROUND SUPPORT





RESIN BOLTS



Two brands used at Rosebery

De-bonded Secura Bolt (23.5mm bar)

De-bonded DSI CS Bar (23.5mm bar)

Different nut & washer assembly

Both bolts have Minimal resin bond at collar !!





PROJECTILE FAILURES











Projectile failures from Rosebery – Lower Mine

Secura bolt projectile failure







EXTENT OF PROBLEM



- Needed to quantify the problem
- Once assessment completed, levels barricaded for rectification

DRIVE	TOTAL FAILED	EAST	WEST	BACKS
Total	127	57%	38%	5%



HAZARD CONTROL METHODS



Fibrecrete

Plate over

Metal Strap – Required testing!

HAZARD CONTROL - Fibrecrete



Fibrecrete 'cow pats' over bolts

QA/QC

- Poor fibrecrete bond to resin bolt bearing plates
- Unable to assess failures

Operational

- Breaking & re-establishment of services
- Fibrecrete availability

Not practical or suitable!



HAZARD CONTROL – Plate Over



QAQC

- Damage to resin bolt plate
- Drill steels hitting bolts
- Poor plate coverage of resin bolts
- Replacement plate pops off with ground movement

Operational

- Breaking & re-establishment of services
- Jumbo availability
- Bearing plate dimensions <u>Not practical or suitable!</u>



HAZARD CONTROL – Plate Over







Needed a solution that...

- -Does not compromise the integrity of the rock bolt
- -Support fixture still visible for assessment of ground conditions
- -Safe, cost effective & easy to install

METAL STRAP RESTRAINER- MSR



MSR designed to:

- Fully contain a resin bolt projectile failure and bearing plate
- Not damage existing resin bolt
- Safe installation
- Suitable for <u>both types</u> of resin bolts in service

Required testing for typical Rosebery ground conditions



A – direction of forces from
projectile failure
B – Deformation of MSR sustained
during bolt failure

METAL STRAP RESTRAINER- MSR





Examples of MSR's in service at Rosebery Lower Mine







Testing completed with Geotech Pty Ltd NATA accredited lab



Six test programmes

- MSR design
- Dyna bolt
 - Cracked fibrecrete
 - Loose scats behind mesh
- Cable tie option
- Alternate methods

Break down of fastener testing





Solid concrete

Loose scatt

Loose fastener

Behind mesh

Cracked fibrecrete







Fastener through cracked fibrecrete (left) & loose 'scat' (right)







Modified original design for use with cable ties for faster installation

Several alternate options were tested as a part of the programme

Daisy Chains

- Mild steel wire
- Steel cable

These options did not meet all test criteria







<u>95 tests</u> completed on Secura & DSI Bolts

Results:

Successful projectile hazard management for:

- Fibrecrete drives
- Meshed drives

Bearing plates held with a cable tie

SECURA BOLT							
Test No.	Test ID	Fastener	MSR	Single/ Double MSR	Bolt Free-fall Pass	Plate Free-fall pass	Comments
Test 1	\$1	Pass	Pass	Single	Pass	Pass	Fastener installed in solid concrete
Test 2	\$1	Pass	Pass	Single	Pass	Pass	Fastener installed in solid concrete
Test 3	\$1	Pass	Pass	Single	Pass	Pass	Fastener installed in solid concrete
Test 4	\$2	Pass	Pass	Single	Pass	Pass	Stiff support - behind mesh
Test 5	S2	Pass	Pass	Single	Pass	Pass	Stiff support - behind mesh
Test 6	S2	Pass	Pass	Single	Pass	Pass	Stiff support - behind mesh
Test 7	S2	Pass	Pass	Single	Pass	Pass	Stiff support - behind mesh
Test 8	\$1	Pass	Pass	Single	Pass	Pass	Scat behind mesh
Test 9	\$1	Pass	Pass	Single	Pass	Pass	Scat behind mesh
Test 10	\$1	Pass	Pass	Single	Fail	Pass	Scat behind mesh. Cable tie slipped during test due to damage to test block
Test 11	\$1	Pass	Pass	Single	Pass	Pass	Cracked fibrecrete behind mesh
Test 12	S1	Pass	Pass	Single	Pass	Fail	Cracked fibrecrete behind mash. Cable plate restraint failed due to being too tigh cable tie must be loose
Test 13	\$1	Pass	Pass	Single	Pass	Pass	Cracked fibrecrete behind mesh
Test 14	S3	Pass	Fail	Double	Fail	Pass	Loose rock behind mesh. Difficult to instal practicality issues, straps do not interact w with each other - mesh sheet was n properly secured for test
Test 15	S3	Pass	Pass	Double	Pass	Pass	Loose rock behind mesh. Difficult to insta practicality issues, straps do not interact w with each other.
Test 16	S3	Pass	Pass	Double	Pass	Pass	Loose rock behind mesh. Difficult to insta practicality issues, straps do not interact w with each other. One strap fell off, the oth controlled failure
Test 17	\$1	Pass	Pass	Single	Pass	Pass	Loose fastener
Test 18	\$1	Pass	Pass	Single	Pass	Pass	Loose fastener
Test 19	\$1	Pass	Pass	Single	Fail	Pass	Loose fastener. Failure sample fell out strap after failure - tie wire
Test 20	S3	Pass	Pass	Double	Pass	Pass	Loose fastener
Test 21	S3	Pass	Pass	Double	Pass	Pass	Loose fastener
Test 22	S3	Pass	Pass	Double	Pass	Pass	Loose fastener
Test 23	S3	Pass	Pass	Double	Pass	Pass	Cracked fibrecrete behind mesh
Test 24	S3	Pass	Pass	Double	Pass	Pass	Cracked fibrecrete behind mesh
Test 25	S3	Pass	Pass	Double	Fail	Pass	Cracked fibrecrete behind mesh

UNDERGROUND INSTALL



Risk assessment

- -Minimise personnel exposure
- -Effective hazard mitigation
- -Level plans
- Development of TARP for further failures
- Training package for operators





DRIVE TYPE	RESIN BOLT PROJECTILE HAZARD	BARRICADE REQUIRED	COMMENTS
TYPE 1	IMMEDIATE HAZARD	NO ENTRY	IMMEDIATE HAZARD OF RESIN BOLT PROJECTILE FAILURE
TYPE 2	FUTURE POTENTIAL HAZARD	NO UN-AUTHORISED ENTRY	POTENTIAL FOR RESIN BOLT PROJECTILE FAILURE IN FUTURE – CURRENTLY NOT AN IMMEDIATE HAZARD
ТҮРЕ З	LOW HAZARD	NONE	RESIN BOLT INSTALLED IN LOW STRESS/ DEFORMATION REGIONS OF THE MINE – DECLINES, CROSS CUTE, LOW DEFORMATION ORE DRIVES ETC.
COMPLETE	LOW HAZARD	NONE	RESIN BOLT PROJECTILE HAZARD ADDRESSED

TARP





TRAINING PACKAGE



Operators trained to install

straps

- •Video
- •Bolt identification
- •Level plans
- •TARP

Operator feed back on safe install



TRAINING PACKAGE



SECURA BOLT

- BIG STRAP
- 1 piece nut and washer
- Fit cable tie to nut of Secura bolt
- Ensure cable tie is firm

<u>DSI BOLT</u>

- SMALL STRAP
- 2 piece nut and washer
- Fit cable tie to bolt tail
- Ensure cable tie is firm



Secura Bolt



DSI Bolt

TRAINING PACKAGE

- Use for ALL TYPES of resin
 bolts
- 3 thick cable ties per strap ZIP UP TIGHT
- 1 thick cable tie per plate LOOSE TO MESH

NEVER STAND DIRECTLY IN FRONT OF A LOADED RESIN BOLT





COMPARISON



	MSR	PLATE OVER	FIBRECRETE
COST OF CONSUMABLES	\$11	\$10.00	\$30
No. PER SHIFT	~300	~150	~100
PROS	 Easy to install Minimal training required for operators Consistent install between operators Test proven method Minimal service work/ disruptions required 	Remote application	Remote application
CONS	 Battery life of hilti drills for installing with fastener 	 Inconsistent install between operators Not 100% effective for all bolts Prep work required before jumbo - services etc Damage to rock bolts Equipment & operator availability 	 Inconsistent install between operators Prep work required before jumbo - services etc Cold joins Equipment & operator availability

SUCCESS AT ROSEBERY!



- <u>100%</u> projectile failure containment
- 30+ fully contained failures
- All crews able to install MSR's
- Faster installation with cable ties
- Positive feed back from
 <u>operators!!</u>



SUCCESS AT ROSEBERY







Bolt optimization project

Bolt design change

- Soft bearing plate
- Change in de-bond length

Alternate bolt trials



Current de-bonded resin bolt design









- MMG Technical & Operational team
 - -Support of the test program
 - -Underground installation
- Geotech Pty Ltd
 - -Design input & testing facilities